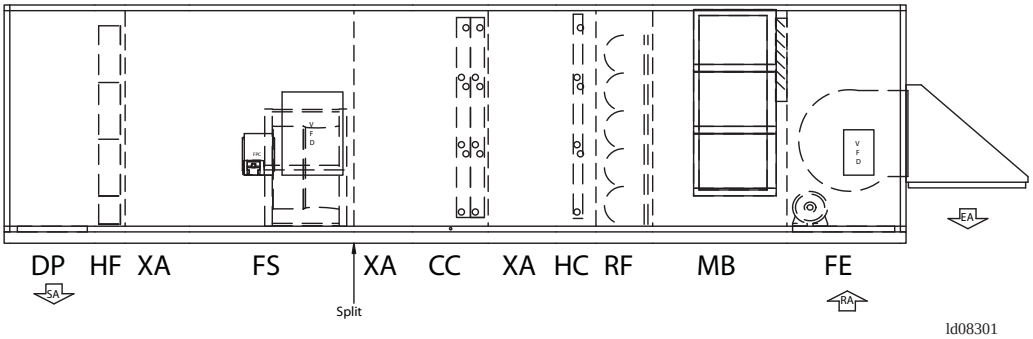
YORK®

BY JOHNSON CONTROLS



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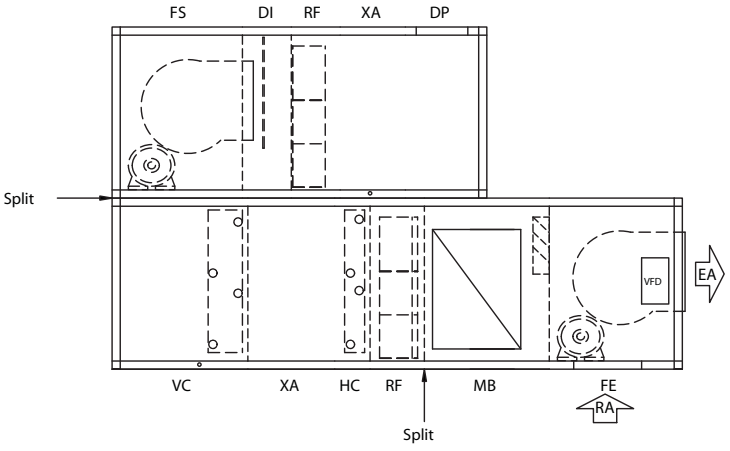

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SOLUTION AIR HANDLING UNITS

2000 TO 100,000 CFM

(Indoor & Outdoor Models)

INTERTEK ETL LISTED C US

ISO 9000 REGISTRATION

ARI PERFORMANCE CERTIFIED www.ahridirectory.org

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GENERAL INFORMATION

Introduction

This Equipment Guide will provide engineers with a summary of Solution air handling information in the most convenient, time-saving manner possible. The guide will direct you to various sources of data and information helpful in solving questions concerning product options, design application, as well as installation and operation.

A Proud History of Experience & Qualifications

Johnson Controls combined with YORK heating, ventilation, air-conditioning, and refrigeration (HVAC&R) systems and solutions creates the largest global provider of integrated products, systems and services for the $200 billion global building environment industry.

Johnson Controls/YORK is:

- A global leader in control systems and services for heating, ventilating, air conditioning (HVAC), lighting, security and fire management for non-residential buildings, facility management and consulting services.
- Represented in over 125 countries, including North America, Asia, Europe, the Middle East, Africa and Latin America and in all markets.

YORK® Solution® air-handling units (AHUs) from Johnson Controls–the only names you need to know for a line that has no limits. Johnson Controls/YORK engineers have developed an AHU line that is so flexible, and able to deliver such high standards of performance, that it can handle virtually any application. Whatever the air-handling challenge–IAQ, acoustics, energy, controls, you name it–Johnson Controls/YORK can build a Solution AHU that will meet your needs.

Solution® AHU's from Johnson Controls comprise a complete AHU line to meet commercial, institutional and industrial indoor and outdoor unit applications. For more than 50 years, YORK air handling units have been installed in every type of facility to handle any type of requirement; manufacturing, education, healthcare, life sciences and process manufacturing.

Solution® AHU's come equipped with industry-leading Metasys® controls that are installed and commissioned at the factory. Factory installation assures superior quality, saves time on the jobsite and delivers accurate performance. Plus, you can count on seamless operation with a Metasys building management system.

Assurance of Johnson Controls Backing

With every Solution system, you get the support and resources that come from dealing with a worldwide manufacturer – JOHNSON CONTROLS. You are not tied to the limitations of a regional supplier. Instead, you get the flexibility being able to design in one part of the country, and buy and install in another location.

Johnson Controls Factory Service

Turn to the experts at Johnson Controls/YORK. Johnson Controls/York carries the burden of single-source responsibility since Johnson Controls/YORK packages the total system, including custom air handlers, chillers, controls, and variable air-volume boxes and building automation systems. For added peace of mind, Johnson Controls/YORK offers Inspection Only, Preventive Maintenance and Inspection, or Total Service Contracts to meet your specific financing and management requirements. Johnson Controls service can also provide certified technicians available locally for factory start-up, drawing from over 700 factory-trained service technicians in 100 strategically-located offices nationwide – a capability not offered by independent manufacturers.

Full Service Support

Because JOHNSON CONTROLS factory packaged devices and motor controls are an integral part of the equipment, who better to troubleshoot and service the system than a professional Johnson Controls Service Technician. The Johnson Controls Service technician knows not only the equipment and the hardware, but also has a working knowledge of equipment application and operation. Every unit is backed by this kind of professional support.

Development and Preparation of Service Literature

Johnson Controls/YORK produces quality product literature to ensure proper installation, operation and maintenance. Installation, Operation and Maintenance manuals must be followed to realize the full capacity and life of the units. In addition, literature supplements of special characteristics and features are distributed as required to support regular product enhancements.

GENERAL INFORMATION

Computer Selection Programs

YORKworks™ software is the primary source for the latest product design and performance data.

1. Includes the latest innovations, updates, and efficiencies of YORK® products
2. Includes general functionality used to select equipment factory packaged controls.
3. Sound data for air-handling units
4. All screens are interconnected and are continually updated according to configuration inputs.

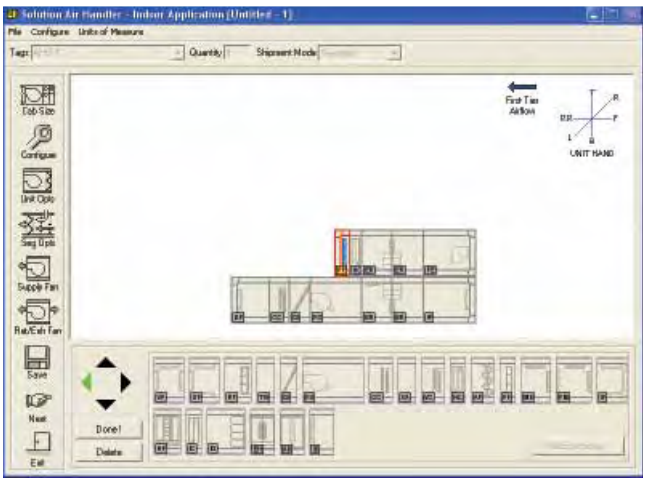
This powerful software tool brings flexibility and computing power to the desktop of designers. The software allows you and the customer to make product decisions and view performance data in a user-friendly, step-by-step, screen-driven environment.

YORKworksCE™ software is a necessity for your customer's engineering toolbox. YORKworks revolutionizes the way you specify HVAC equipment. Johnson Controls/YORK can optimize the selection of any air handling unit for a specific job requirement with its computer selection programs.

Just Click to select and add components

Quick and Easy selection

- Save Time – choose components and complete configurations with a couple of clicks.
- Reduce Errors – use pre-programmed rules and guidelines for component selection.



Literature Reference — see *'Sales Guide – YORK works CE'* Form 70.02-SG1

Innovative Engineering & Design

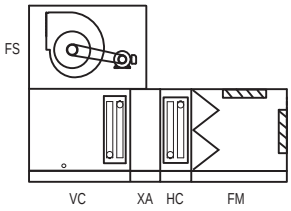
Solution Air Handlers are not just 'fans-in-a-box'!

1. Solution is a structure that withstands deflection
2. Solution is a sound/noise barrier
3. Solution is a container of clean and conditioned air
4. Solution is an integral part of a building's fire and safety plans
5. Solution's Variable Aspect Ratio eliminates the need for costly modifications.
6. Solution fits the specification and the space!

Innovative Engineering & Design allows you to choose from a limitless variety of configurations. See configurations below for some of the popular applications designed to meet your particular need.

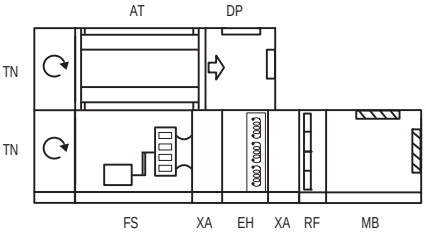
Configuration 1 (Stacked Unit) –

Mechanical room favorite. Reduced footprint with tiered supply fan

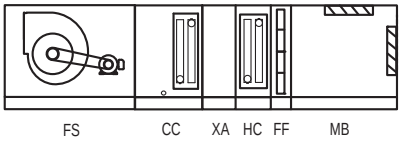


Configuration 2 (Stacked Unit) –

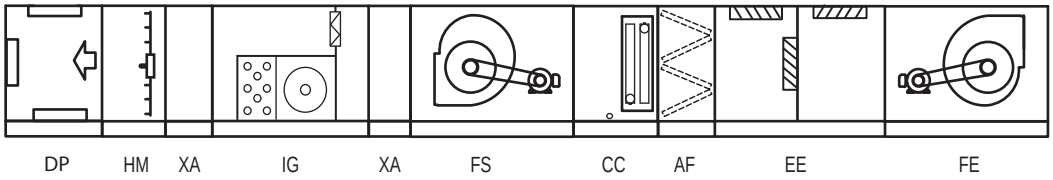
Ultra-quiet design with plenum fan and U-shaped cabinet



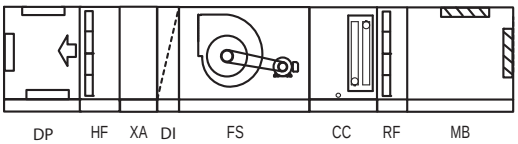
Configuration 3 – Minimum frills. Maximum IAQ



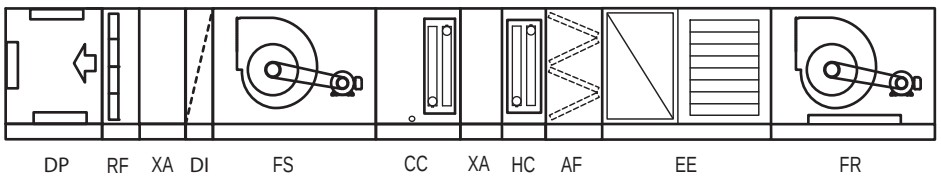
Configuration 4 – Exhaust air flexibility with gas-heat and humidification



Configuration 5 – Cooling-only lab design with HEPA filtration



Configuration 6 – Classic hospital design with return fan economizer operation.



GENERAL INFORMATION

Flexibility of Design

Solution AHUs offer the ultimate in dimensional, material, and component flexibility. Solution AHUs have the same appeal for both “standard” and “custom” markets. How an air-handling unit is designed and built determines how well it performs.

Engineering Flexibility

- Variable cabinet dimensions
- Material and component flexibility
- Full line of factory packaged controls installed, tested and commissioned by Johnson Controls certified technicians
- Variable sized inlet and discharge openings
- Indoor and outdoor constructions
- Tiered (stacked) and custom configurations

- Panels are individually removable without affecting structural integrity.

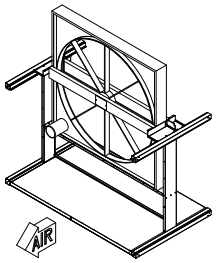
Dimensional Flexibility

You can design Solution AHUs to fit the application and the space. Length, height and width can all be varied to match building constraints. With hundreds of cross-sectional possibilities, you choose the best match for the application. In addition, all Solution AHU components have been designed with a variable-aspect ratio to meet your space and air-velocity requirements.

Material Flexibility

A complete line of construction materials are available, including galvanized steel, aluminum, painted steel, stainless steel, and more. Solution AHUs can handle a multitude of environments, from the most benign to the most corrosive. NOTE: All units/unit segments are shrink-wrapped to protect unit from contamination during shipping

Component Flexibility



AHUs are responsible for providing the environment with quality indoor air, in an energy efficient and quiet manner. Solution AHUs help meet that responsibility by offering every available component, from energy wheels to air-monitoring stations to specialty-purpose filters. As technology creates new capabilities, Johnson Controls/ YORK will apply these to our Solution line.

Superior Casing Performance

The foam injected panels of our Solution air handling units enhance performance, maximizing the indoor air quality and help to create ASHRAE 62-2000 compliant designs while reducing costs. The direct result of the foam injection insulation is a rigid panel, low leakage, high pressure air handler, with increased energy savings, and reduced initial cost.

Better IAQ

Deflection presents a potential in leaks that form over time from the operational pressure. The foam injected Solution panels are 20% more rigid (L/240 vs. L/200) then the typical fiberglass or foam board construction. In addition the smaller deflections can be achieved using lighter sheet metal gauges then required by fiberglass construction. The result is a lower initial cost unit with greater performance.

Lower leakage reduces the infiltration of unfiltered and unconditioned air into the space. The infiltration of unconditioned air can lead to condensation in unit walls, crevices and/or insulation. When the infiltration occurs in a negative pressure atmosphere downstream of the filter, it will lead to unfiltered air being supplied to the space. Maintaining a low leakage for positive pressure segments reduces the loss of conditioned air to a potentially warm and humid ambient environment, causing increased condensation. Condensation can lead to premature corrosion as well as IAQ concerns.

The Solution foam injected wall panels help to seal and maintain the leakage at maximum of 1% with a minimum +/-8” of static pressure. Options for a maximum leakage rate of 1/2% at a minimum of +/-10” of static pressure are available for those projects which demand it.

Coil carryover, humidification, and periodic wash downs are all instances where water is present in the unit. Foam insulated panels will not absorb, and retain water, like a fiberglass insulated panel will. In addition the thermal properties of foam are not degraded by an incident where the insulation comes in contact with water.

Energy Savings

The energy savings associated with high performing air handler construction is directly associated with leakage and insulating properties.

The infiltration of unconditioned air downstream of a coil, or the loss of conditioned air downstream of a coil are just two examples of reduced energy efficiency in an air handler. The foam injected panel helps to reduce both of these potential losses by creating a more rigid, lower leakage air handling over the life of the unit.

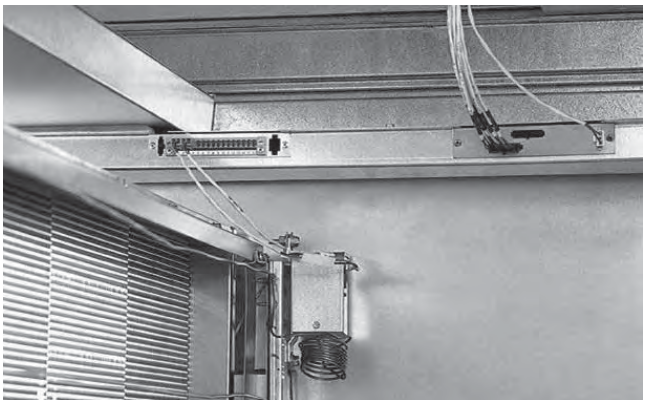
Another form of energy loss associated with air handlers is the thermal energy that is lost through the cabinet of the air handler. The Solution foam injected panels lower energy consumption with better insulating properties. With the standard R-12.5 and optional R-18.8, or R-25, the Solution can help to reduce the energy usage. The injected panel provides additional thermal advantages in that the foam will fill voids, and gaps that aren't reached with fiberglass or foam board type constructions.

Solution air handler units are capable of being factory tested to prove out both leakage and deflection. With the Solution product it's not all about construction, it's also about performance.

Pre-engineering Packaged Controls

Pre-engineering of sensors ensures the most accurate performance. There are great advantages to selecting factory mounted and wired end devices for your Solution air handling units.

1. Factory mounting maintains leakage performance
2. Factory wiring is plug and play
3. Factory testing of each mounted and wired device
4. Factory generated control diagrams specifically for each unit



Factory Installation

Factory installation improves quality and saves time. While a Solution AHU is being manufactured, Johnson Controls technicians can easily access all its segments. So there are no accessibility problems to cramp the quality of the controls installation, which often occurs on the jobsite.

All sensor probes have been pre-engineered to determine the best mounting location, ensuring accurate and reliable readings.

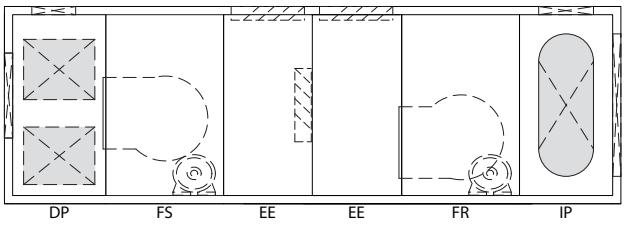
This improves performance of the unit while eliminating unwanted air leakage common in field-mounted solutions.

Factory engineering speeds field connections

The goal is to provide you with an AHU that simplifies field connection of the controls. For example, coil valves are shipped uninstalled, but pre-wired with quick connects. If an AHU is too large to ship in one piece, you can still count on fast and easy assembly of Metasys controls because labeled quick connects come standard on all shipping splits.

Customized variable size openings

Solution offers the most comprehensive option for factory provided openings. Custom size, custom location and custom shapes along with custom sized dampers,are designed to lower installation costs and risk while dramatically improving the quality of the application and performance of the air handler.



Literature Reference — see Application Guide *'Applying VSO Option to Solution Air Handling Units'* - Form 102.20-AG14

GENERAL INFORMATION

Airflow Measurement Performance

Solution AMS-60 qualifies to bear the AMCA Ratings Seal for Airflow Measurement Performance. Ventilation air flow can be controlled dynamically with the Solution AMS-60 which is tested to AMCA Standard 611-95. The Solution AMS-60 continues to be the best integral air-flow station offered for air handling units which is incorporated into mixing box and economizer segments to meet the most stringent ASHRAE 90.1 requirements

There are 3 damper options to give various measurements of air flow. See FIG. 1.

NOTE: Dampers are split vertically

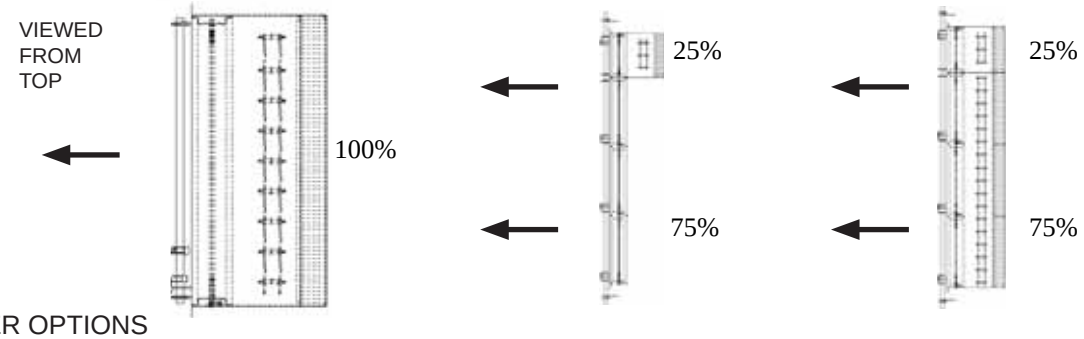


FIG. 1 – DAMPER OPTIONS

Literature Reference — see Application Guide *'AMS60 for use with Solution AHU'* - Form 102.20-AG1

State-of-the-Art Certification & Testing

Solution Air Handlers are subject to stringent testing using certified, comprehensive and industry recognized testing laboratories. Testing is in accordance with ARI Standard 430 which evaluates the performance of the entire unit. This assures that each Certified Solution unit will indeed perform with certainty and reliability.

Solution AHUs have also undergone extensive and rigorous testing to verify conformance with all U.S. and Canadian safety standards, and they bear the ETL Label.

Extensive testing includes:

- ARI 430 certified performance
- ARI 260 sound data
- Full line of ARI 410 certified coils
- ETL listing for product safety per UL 1995
- ASHRAE 90.1 compliant
- ASHRAE 62 compliant coil and drain pan design maximizes indoor air quality
- Outstanding thermal capacity proven through independent testing
- HEPA filtration system exceeds the most stringent military DOP tests
- AMCA 611 certified airflow measurement stations
- ISO Quality Certification
- Seismic certificate of compliance

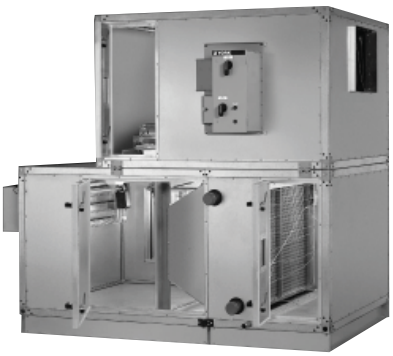
Labeled Solution units are tested and listed by ETL in accordance with UL 1995, Standard for Safety Heating and Cooling Equipment, and thereby fully complying with NFPA 90A material requirements.

New Sound Testing Laboratory

The new AHU laboratory at the Johnson Controls Grantley Park Tech Center includes the capability for sound power measurements on Air Handling Units up to 100,000 CFM in accordance with ARI 260. The facility will also include the capability for testing unit airflow in accordance with AMCA 210 to 100,000 CFM. For fan alone testing, the facility will also have AMCA 300 and AMCA 210 accreditation. All of this capability will be available for product development testing and for customer witness testing on critical projects. This facility will allow verification and calibration of sound models used for unique features of Solution units, which will increase the accuracy of our predictions and ensure that our customers will continue to obtain the best available Solution sound data in the marketplace.

This facility will be the largest AHU sound test facility in the world. Note that in order for a laboratory to measure ARI 260 sound data, the laboratory must be pure tone qualified to 50 Hz. This facility will be pure tone qualified to 50 Hz. Pure tone qualification ensures that the test facility is capable of accurately measuring a noise source producing tones – such as a fan. Not qualifying the facility for pure tone response could lead to erroneous results with a tonal noise source. This is why ARI requires pure tone qualification of reverberation rooms in the HVAC industry for anything other than VAV boxes.

Quality Construction Equals Improved IAQ



Quality construction is a key to a minimum amount of AHU leakage. Leakage is an adversary of indoor air quality. It will depreciate the quality of the supply air by allowing dirty, unfiltered air to seep into the air-stream downstream of the filters.

To prevent this leakage, the rigid, thermally superior panels of Solution AHUs are matched with a rugged framework to provide an extraordinary casing performance.

The maximum allowable air leakage is less than 1% at +/- 8" w.g. and a maximum L/240 deflection.

The Shell of Solution is made up of double wall panels and doors.

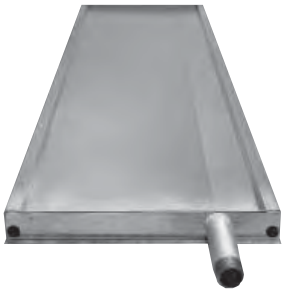
- Standard liner material is galvanized
- Stainless liners are optional
- Perforated aluminum liners are optional

The floor is a double wall construction, with a galvanized steel walk-on surface.

- Optional stainless steel
- Optional aluminum tread plate

Multi-Sloped Drain Pans

The way to control micro-organisms, which can flourish in drain pans, is to control the moisture of cooling-coil condensate which can remain in the pan during “off” or “heating” cycles.



Poorly designed drain pans are often breeding grounds for mold and poor IAQ. ASHRAE 62-2001, section 5.11.1 states that drain pans “...shall be sloped at least 1/8" per foot from the horizontal toward the drain outlet whether the fan is in the on or off position.” Section 5.11.2 states that “The drain pan outlet shall be located at the lowest point(s) of the pan.”

Solution units remove the condensate with a multi-sloped drain pan that ensures positive drainage. Our pan design also offers the highest level of accessibility for periodic cleaning, now required by ASHRAE Standard 62.

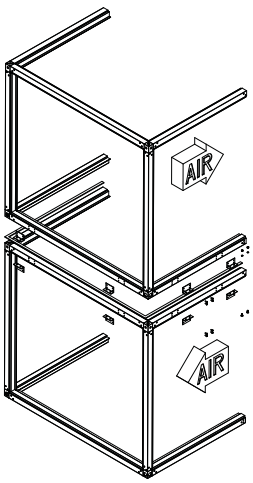
Raceways

Raceways are used as the exterior skeletal construction of Solution.

- Raceways provide the form and shape as well as structural support for panels, base and internal.
- Raceway material is Galvanized

Solution is offered with a full-perimeter base-rail with integral lifting lugs.

- Optional base-rails
- Lifting lugs are provided as necessary for material handling



A ‘Curb Rest’ is provided to direct, guide and indicates alignment when setting a unit on the curb.

- Galvanized steel strip attached to the raceway or base-rail
- ‘Curb Rest’ is not to be considered a flashing receiver for the curb.

Improve Cost Savings

Solution UV-C light options eliminate the potential for a build-up of microbiological agents.

1. Heat exchangers continue to operate at high-efficiency levels due to sustainable, like-new, reduced pressure drop.
2. HVAC equipment operates for shorter periods of time saving cost on electricity.
3. Improved IAQ as the first line of defense against sick building syndrome.

Installation of UV-C lamps promotes a cleaner, healther, more productive work environment.

More detailed information on page 57 of this manual.

Literature Reference — see Application Guide *‘Solution IAQ Series General AHU Construction’* - Form 102.20-AG3

GENERAL INFORMATION

A Complete Line of Filters

A complete line of clean air solutions for industrial plants, hospitals, schools, pharmaceutical process, airports and commercial buildings are available to control or remove airborne contaminants from the air stream.

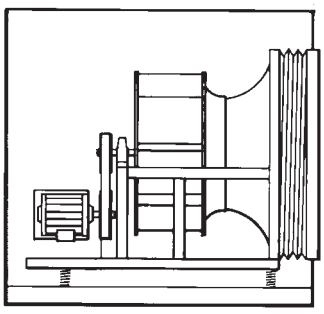
Achieving acceptable indoor air quality is more involved than calculating and applying the appropriate ventilation rate. Specific AHU performance and other common sense specification items, tied to ASHRAE 62.1 recommendations, can help achieve the healthy indoor air quality environment desired.

Light pre-filtering duty: – pleated – extended surface Higher filtration efficient – 60% to 95% – 11 to 14 MERV – rigid & bags	Stringent filtration requirements: – HEPA – Ultra-HEPA – 17 to 18 MERV – 0.3 & 0.1 microns respectively – 99.97% & 99.99 % effectiveness	Odor or VOC removal – Activated carbon Air purification systems High-performance – Near-HEPA performance – Germicidal capability – Low-resistance-to-airflow (initial pressure drop equal to a low-end pre-filter).

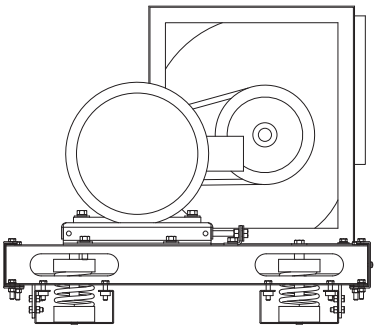
Energy-Saving Fan Options

In any AHU, the fan is the largest energy consumer.

Solution fans offer a range of energy-saving options through fan types and controls.

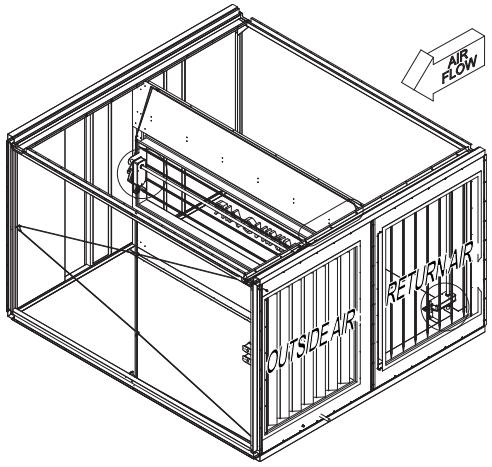


- Light aluminum fan wheels
- Direct-drive plenum fans, which eliminate belt-and-pulley energy losses



To assure the quietest possible operation, fans and motors are common base isolated from the cabinet.

Economizers (EE) provide an exhaust path for return air, allowing the outdoor air conditions, when suitable, to take advantage of 100% outside air for “free” cooling, allowing the chillers to be turned off a percentage of the time during the cooling season. Return and exhaust fans are available to meet the needs of varying building pressurization requirements.

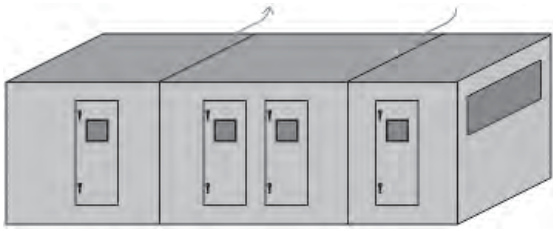


Literature Reference — see Application Guide *‘Solution - Reducing AHU Energy Consumption’* - Form 102.20-AG13

Energy Consumption

The HVAC industry has taken a leadership role by creating energy-performance guidelines, such as ASHRAE 90.1. Solution AHUs are designed with ASHRAE 90.1 in mind.

In extreme ambient conditions, heat transfer through the casing must be controlled. Solution casing offers maximum thermal performance in the floors, walls and roof. To prevent energy-robbing air leaks, Solution units are designed for a maximum casing leakage of less than 1%.



For every 1% of air leakage at the AHU, 1% more air must be conditioned, and 1% more energy is consumed.

Comparing Apples-to-Apples

Competitors claim “Air leakage rates between 1/2 and 1 percent” on their AHUs, but they don’t mention at what pressure this performance is achievable, nor do they even specify a leakage rate for the air units.

This typically makes it difficult to analyze their leakage performance by not qualifying it based on air pressure. However, if we reference to SMACNA class 3 air leakage this is a good place to begin our analyses.

SMACNA class 3 refers to a standardized method of classifying duct leakage. While this classification doesn’t technically apply to AHUs, it is a useful method of comparing the performance claims of different manufacturers. According to SMACNA Duct Leakage Test Procedures (1985), duct leakage is calculated using the equation:

Eq. 1 $L_{max} = C_L P^{0.65}$

where,

L_{max} = maximum permitted leakage in cfm/100ft^2 duct surface area;

C_L = duct leakage class, cfm/100ft^2 at 1 in-w.c.

$P^{0.65}$ = test pressure in in-w.c.

Rearranging Equation 1 to solve for duct leakage class:

Eq. 2 $C_L = L_{max}/P^{0.65}$

$C_L = (0.5 \text{ cfm/ft}^2 \times 100 \text{ ft}^2)/5^{0.65}$

$C_L = 17.6$

According to this, regardless of unit size or capacity, this type air-unit is roughly equivalent to a SMACNA leakage class of 18.

Analyzing Solution units is a little more complex than analyzing the other typical unit, since Solution strives for a maximum leakage rate of 1% of the unit design airflow at ± 8 in-w.c. That means that the leakage in cfm/100 ft^2 of unit casing varies based on the size and capacity of the unit. A 4,000 cfm Solution unit will have a maximum leakage rate of 40 cfm, whether the unit is 8’ long or 10’ long. Therefore, the 10’ long unit will have an inherently lower cfm/100 ft^2 leakage rate than the 8’ long unit, as shown in Table 1.

Table 1. Comparative Solution Leakage Rates

Unit CFM:	4000	4000	16000	16000	32000	32000
H (Inches)	36	36	66	66	114	114
W (inches)	54	54	96	96	102	102
L (inches)	98	124	105	132	125	150
Area (ft²)	150	182	324	385	537	612
1% Leakage (cfm)	40	40	160	160	320	320
Leakage (cfm/ft²)	0.27	0.22	0.49	0.42	0.60	0.52

Using the Solution performance at ± 8 in-w.c. we can use the SMACNA leakage class as a standard comparator. By plugging the values from Table 1 into Equation 2, we find the leakage class for the various Solution units as shown in Table 2.

Table 2. Solution AHU Leakage Classes

Unit CFM:	4000	4000	16000	16000	32000	32000
Leakage (cfm/ft²)	0.27	0.22	0.49	0.42	0.60	0.52
Leakage Class at ± 8 in-w.c	**7**	**6**	**13**	**11**	**15**	**14**

Even on large AHUs, the leakage class of a Solution unit is lower than that of most competition. Many design engineers don’t realize this, because when they compare YORK’s performance to others they aren’t comparing apples-to-apples unless the performance is translated into the common language of leakage class.

Literature Reference — see Application Guide Form 102.20-MG1. See also M-42-06.

GENERAL INFORMATION

EPAct Efficient Performance

Consumption of energy can also be reduced by more efficient motors. Solution AHU motors meet EPAct efficient performance standards for general purpose motors. Standard Solution EPAct efficient and Premium-efficiency motors can be specified and used with frequency control as listed by NEMA Standards Publication MG 1-2006 (Motors and Generators):

- MG 1-2006 Part 30

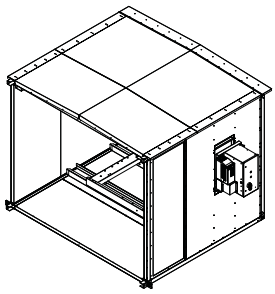
  Application Considerations for General Purpose Motors used with Adjustable - Voltage OR Adjustable - Frequency Controls or Both

- MG 1-2006 Part 31

  Definite-Purpose Inverter-Fed Poly-phase Motors

Literature Reference — see Application Guide *'Solution Air Handling Units AC Induction Motor Data'* - Form 102.20-AG15.

Energy Saving Air-Modulator™

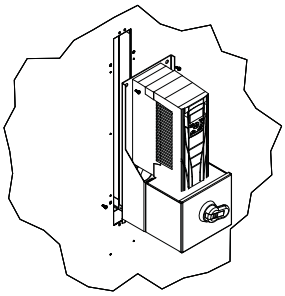


When the air system is designed for variable-air volume (VAV), Solution offers the most efficient method of VAV fan control with our Air-Modulator™ drive, which is mounted, wired and tested in our factory.

Fans characteristically require much less power as the speed is reduced. With the Air-Modulator™, any reduction in fan speed results in a cubic reduction in fan horsepower. For example, a 10% speed reduction results in a 27% fan horsepower reduction!

Air Modulator benefits include:

1. Extended Equipment Life – soft start of motor and fan.
2. Quieter Fan Operation – fan operating at reduced speed and constant line of efficiency.
3. Eliminates need for motor starter panels.
4. Improved system control and response – DDC controls with LED digital display.
5. Proven reliability.



Typically HVAC systems consume a third of the energy used in commercial buildings. Therefore an energy-efficient HVAC system can represent a significant savings in building operating costs. ASHRAE 90.1 provides architects and engineers with guidelines for the design of energy efficient buildings, with the exception of low-rise residential buildings.

Literature Reference — See Application Guides *'ASHRAE 90.1 Guidelines'* – Form 102.20-AG2 & *'Understanding AHU Casing Leakage'* – Form M-42-06

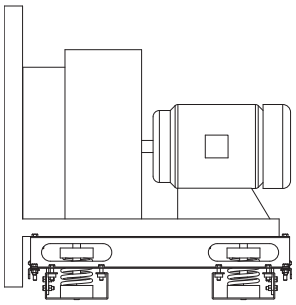
Sound Attenuation

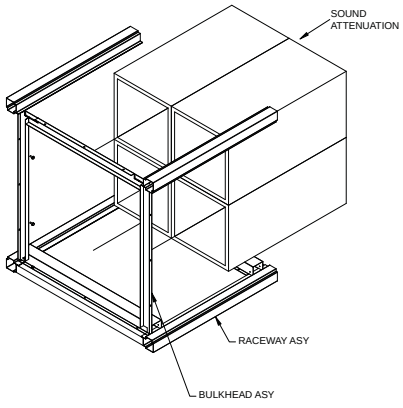
An important component of indoor environmental quality (IEQ) is acoustics. There are very few constants when it comes to acoustics, however it is always less expensive to design and install a system correctly the first time than it is to make the system quiet after it is installed. The best way to reduce noise is not to create it in the first place.

ARI 260 requires that the unit be rated across its entire operating range according to the AMCA 300 test method. Johnson Controls/YORK has been and continues to be fully engaged in a rigorous ARI 260 testing program. Solution testing includes a wide variety of fan types, unit sizes and configurations. As a result, Solution can with assurance say sound power levels are reported in accordance with ARI 260.

Solution AHU offers a variety of noise-reducing technologies.

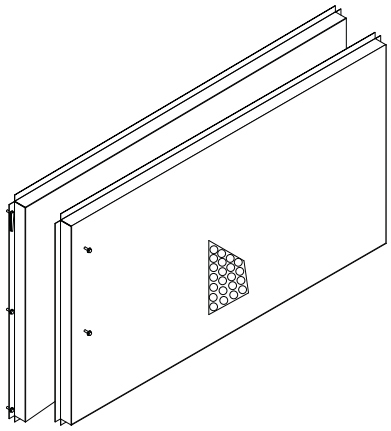
Solution AHUs are available with a nearly endless array of fan types, all custom selected for the exacting requirements of your project. Direct drive plenum fans can reduce vibration and drive noise by eliminating the belt-and-pulley mechanism. A range of fan-base construction and isolation techniques are available to help control sound.





Source attenuation is the first sound-reduction method that should be considered, and is typically least expensive. Since the fan is the primary moving part in an air-handling system, it's the first place to look when reducing noise.

What little noise is left can be further reduced with direct methods of sound attenuation. Using perforated sound-absorbing walls as sound traps in the fan and discharge-plenum sections, Johnson Controls/YORK equipment engineers can help you design units to meet your critical sound requirements.



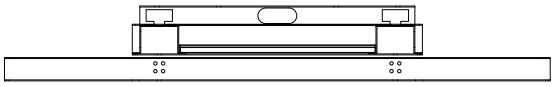
Inertia Base

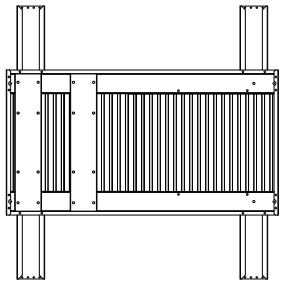
A concrete inertia base, which is inserted between the fan and its supportive structure, can be quickly and economically installed in all Solution unit cabinet sizes.

– Inertia fan bases will accommodate both belt driven and direct drive fans

– The added mass of the inertia base allows for a softer isolation system and greater isolation efficiencies as well as an effective means of dampening mechanical noise.

– Concrete fill is furnished by contractor.





Application Note - As a rule of thumb the inertia base should be used when:

- Class II & III fans with 40" diameter wheel or larger
- All centrifugal fans driven by motors of 75HP or larger

GENERAL INFORMATION

Quick Selection

The Quick Selection Guide for the Solution AHU was developed and intended to aid the Consulting Engineer, Architect, Design/Build Contractor, and Equipment /Controls Engineer in establishing overall estimates for (minimally) footprint dimensions, unit weight, & max motor horsepower.

Contents consist of:

- Applications, Features & Benefits
- Instructions
- Data
- Notes
- Reference Formulas and Conversions

Solution
Custom Air-Handling Units
One Line . . . No Limits
PERFORMANCE AND ACCOUNTABILITY
• < 1% leakage and < L/240 deflection at minimum +/- 8" w.g.
• Minimum R-12.5 insulation
• Factory testing available on request
• Shrink-wrapped shipping protection
ENGINEERED FLEXIBILITY
• Variable cabinet dimensions
• Material and component flexibility
• Full line of factory-packaged controls, installed, tested, and commissioned by YORK® – certified technicians
OUTSTANDING ECONOMICS
• Excellent first cost
• Superior energy savings relative to lesser-performing, "modular" units
• Industry-leading warranty, with YORK – employed technicians conveniently located within miles of any job site.
YORK

Literature Reference — See Quick Select Tool – Solution Slide Chart – Form 102.20-SC1

FAN APPLICATION REVIEW

Fan Laws (Recommended Accepted Practice)

The fan laws are used to calculate performance characteristics; fan speed (RPM), fan air capacity (CFM), static pressure (SP) and brake horsepower (BHP) of a particular fan at conditions other than those at which the data was taken.

By using the fan laws in conjunction with a fan curve, the fan performance can be calculated accurately at various operating conditions. Every fan has its own unique fan curve. FIG. 2 shows a fan curve at various RPMs.

The system resistance curve relates the total pressure loss in an air handling system to the flow rate of air through the system. The system curve is unique to each system because it expresses the pressure losses associated with the system. (AHU cabinet, coils, filters, supply and return ductwork, grilles and diffusers).The SP and CFM values are used to create the system curve for the particular system. FIG. 3 represents a fan curve with 2 system curves identified.

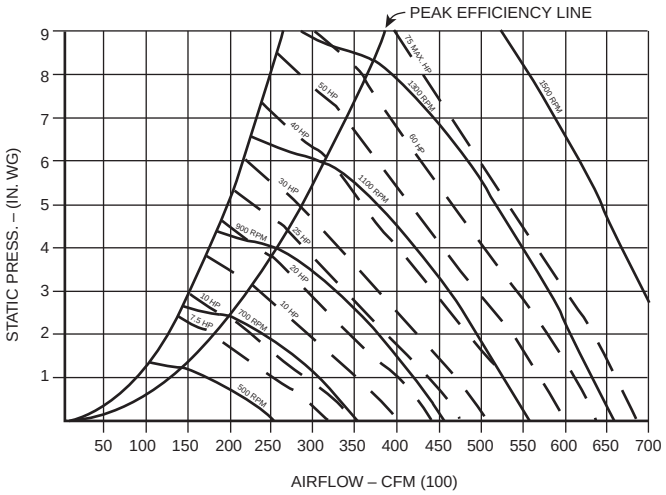


FIG. 2 – CURVE AT VARIOUS RPMs

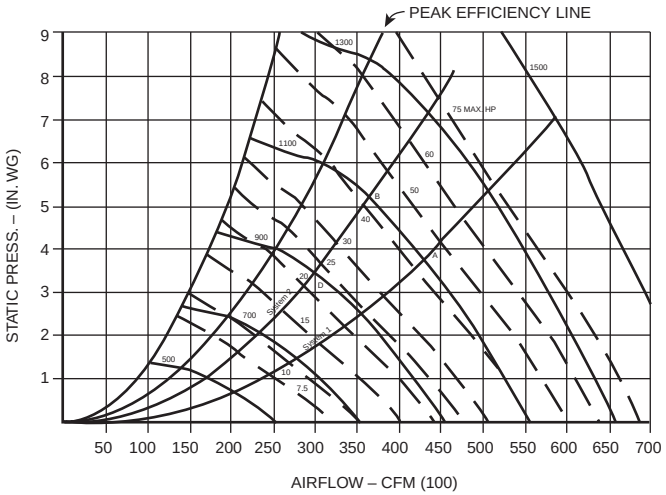


FIG. 3 – FAN CURVE WITH TWO SYSTEM CURVES

System curves will always have a square function slope (parabola) because the SP varies as a square of the CFM. The point where the system curve intersects the RPM curve is the operating point of the fan (point A). If the system resistance changes (i.e., dirty filters or change in ductwork), the operating point will move along the RPM curve to a different operating point and therefore, new system curve (point B). With a fixed system, the effects of change in RPM, air density of BHP can be calculated and plotted on the system curve by using the following fan laws:

- The CFM varies directly with the RPM:

$$CFM_2 = CFM_1 \times \left[\frac{RPM_2}{RPM_1}\right]$$

- The SP varies as a square of the RPM:

$$SP_2 = SP_1 \times \left[\frac{RPM_2}{RPM_1}\right]^2$$

- The BHP varies as a cube of the RPM:

$$BHP_2 = BHP_1 \times \left[\frac{RPM_2}{RPM_1}\right]^3$$

- The SP and BHP are directly proportional to the air density:

$$SP_2 = SP_1 \times \left[\frac{Density_2}{Density_1}\right] \times \left[\frac{RPM_2}{RPM_1}\right]^2$$

$$BHP_2 = BHP_1 \times \left[\frac{Density_2}{Density_1}\right] \times \left[\frac{RPM_2}{RPM_1}\right]^3$$

The fan laws can only be used to project performance along a specific system curve. Referencing FIG. 3, Point A can be used to project the performance of Point C and similarly, Point B can be used to project the performance of Point D. Point A cannot be used to predict any other point on the RPM curve, it can only project performance on the system curve created by Point A.

FAN APPLICATION REVIEW

Variable Air Volume

A common mistake when selecting a fan with variable air volume is to assume a fan with VAV will follow a constant design system curve (passing through the point 0 CFM and 0 TSP) to maintain control. VAV systems do not have a constant system line, but rather a range of operating points necessary to satisfy the building requirements. In VAV systems, the operating point will continue to move based on the air modulation and as the CFM and SP change, the fan is modulated to match the new requirements, developing its own system curve. This modulation is accomplished by using inlet vanes, variable speed drives or discharge dampers. Before finalizing the fan selection, plot the new VAV system curve to confirm the modulation range required does not enter into the instability range of operation.

Example

Calculate the minimum CFM and at least 2 arbitrary points which fall within the stable operating range of the curve (using equations below) and plot these points along with the design points to create the new VAV system. (See FIG. 4.)

Design CFM = 40,000 CFM = CFMd
Design TSP = 4.5 in WG = SPd
Static Pressure Control Point = 1.25 in WG = SPd

Select the most efficient fan that can deliver both the design and minimum CFM requirements. If the initial selection does not provide sufficient “turn down”, select the next smallest fan and re-plot the VAV system for the smaller fan and re-evaluate. Typically, the largest fan that can supply the required modulation is the most efficient. Each application should be considered individually and evaluated to be sure the fan will not be forced into the unstable region at modulated condition.

For variable speed drive (VSD) applications, the fan drive assembly is selected to operate approximately in the middle of the VSD’s range. When selecting a fan to be used with a VSD, if the RPM is close to or approaching the Class I limit, select the Class II fan. Selection of a Class I fan may result in premature bearing failure.

1st: Calculate the Minimum CFM:

$$\text{Min CFM} = CFM_d \times \sqrt{\frac{SP_S}{SP_1 \times \left(\frac{CFM_d}{CFM_1}\right)^2 + SP_S - SP_d}} = 40{,}000 \times \sqrt{\frac{1.25}{3 \times \left(\frac{40{,}000}{15{,}000}\right)^2 + 1.25 - 4.5}} = 10{,}517$$

where: CFM_1, SP_1 = arbitrary point located on surge line
Min CFM = 10,517

2nd: Calculate the Arbitrary Points:

30,000 CFM

where: $CFM_2 = 30{,}000$

$$SP_2 = \left(\frac{CFM_2}{CFM_d}\right)^2 \times (SP_d - SP_s) + SP_s$$

$$SP_2 = \left(\frac{30{,}000}{40{,}000}\right)^2 \times (4.5 - 1.25) + 1.25$$

$$SP_2 = 3.1$$

20,000 CFM

where: $CFM_3 = 20{,}000$

$$SP_3 = \left(\frac{CFM_3}{CFM_d}\right)^2 \times (SP_d - SP_s) + SP_s$$

$$SP_3 = \left(\frac{20{,}000}{40{,}000}\right)^2 \times (4.5 - 1.25) + 1.25$$

$$SP_3 = 2.1$$

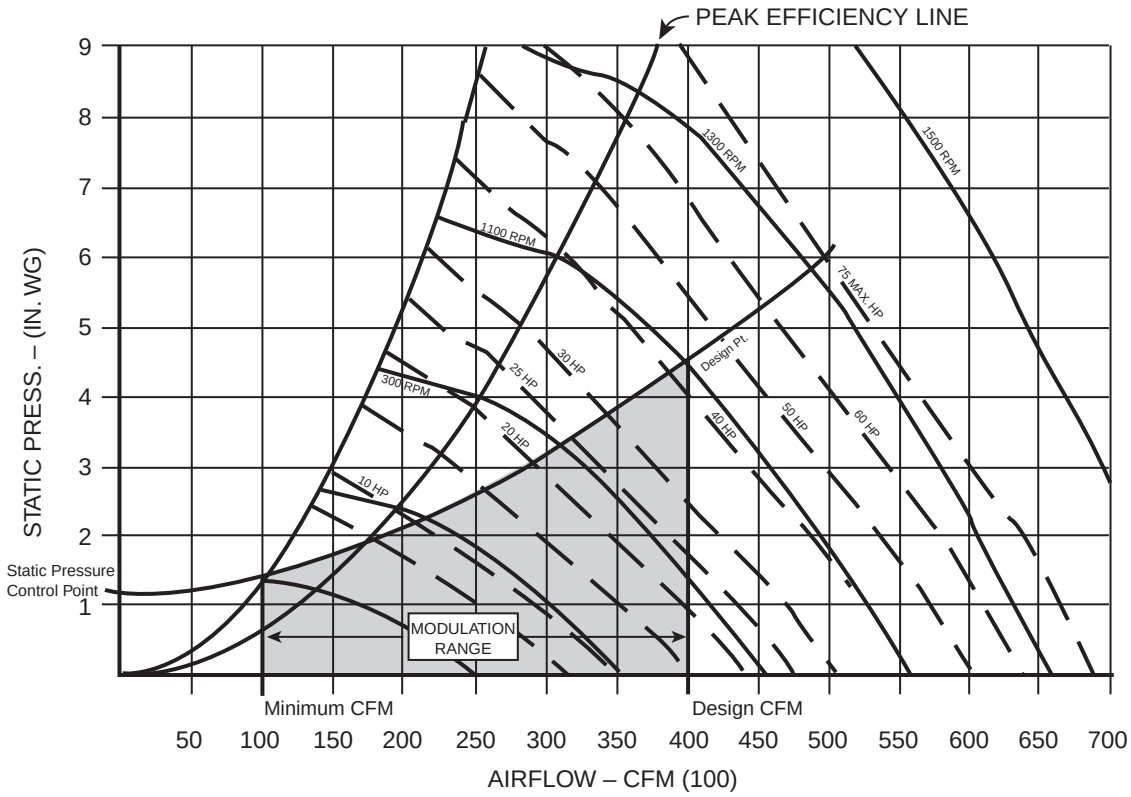


FIG. 4 – FAN CURVE AT VARIOUS RPMs

Solution Component Temperature Margins

- Standard motors (Class B Insulation) -104°F.
- Motors with Class F Insulation -140°F.
- Power Wiring - 140°F.
- Controls & Control Wiring - 140°F.
- Pre-filters - 150°F.
- High Efficiency Filters - 200°F.
- Fan Bearings - 120°F (FC), 180°F (AF)
- Gasketing - 200°F
- Foam - Flash Point: 415°F (213°C)

Fan Motor Heat (MBH)

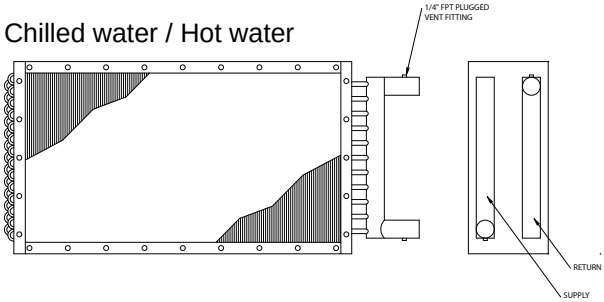
HEAT	Horsepower											
	5	7.5	10	15	20	25	30	40	50	60	75	100
Fan Motor	2.8	3.6	4.4	6.2	7.5	8.7	9.4	13.0	16.0	19.0	21.0	25.0
Fan	12.7	19.1	24.5	38.2	51.0	63.6	76.3	102.0	127.0	153.0	191.0	254.0
Fan & Fan Motor	15.5	22.7	28.9	44.4	58.5	72.3	85.7	115.0	143.0	172.0	212.0	279.0

COIL OPTIONS

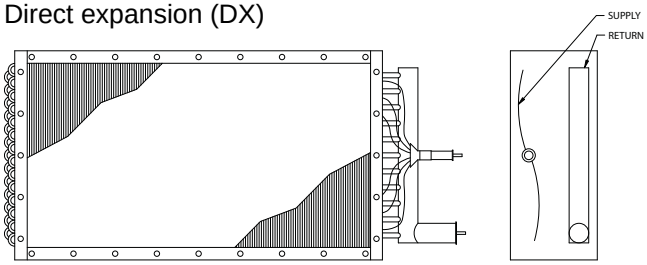
Flexibility and Performance illustrate the variety of coils which are available to meet every application. These carefully engineered coils are designed for an optimum balance between air pressure drop and heat transfer coefficient, to allow the maximum amount of cooling or heating capacity without the added expense of high air-pressure drops. The coil designs are subjected to constant extensive evaluation studies comparing different fin corrugations with various tube arrangements. The Johnson Controls/YORK Equipment Engineer in your area will welcome the opportunity to assist you with your coil applications.

Coil Performance is certified in accordance with ARI Standard 410.

Chilled water / Hot water



Direct expansion (DX)



Cooling Coils – Water and Direct Expansion

Solution optimizes coil performance with customized coil options. Solution coils are offered in a wide variety of types, sizes, arrangements and materials. Coil software optimizes capacity and pressure drop requirements.

AHU Chilled water cooling coil

- Available in CC, VC, MZ segments

AHU Hot water heating coil

- Available in CC, VC, HC, MZ segments

AHU (DX) Direct Expansion cooling coil

- Available in CC, VC, MZ segments

Notes & Options

Hand of Unit determines connection side of coil. See page 21.

Header material:

- Copper
- Red Brass

Connector material:

- Red brass
- Steel

Connection Type:

- MPT
- Grooved

Fin type:

- 5/8” tube: Sine or Flat
- 1/2” tube: Sine corrugated only

Fin Material & Thickness:

- Aluminum - 0.006”, 0.008”, 0.010”
- Copper - 0.006”

Fin Spacing:

- A vast range of fins per inch available

Fin Coatings: (Coatings reduce max face velocities)

- Electro-fin
- Phenolic

Coil Casing:

- Galvanized
- Stainless Steel

Choice of heat transfer medium:

- Water, Glycol (Ethylene glycol coils are ARI certified)
- DX – (a variety of refrigerants to choose from)

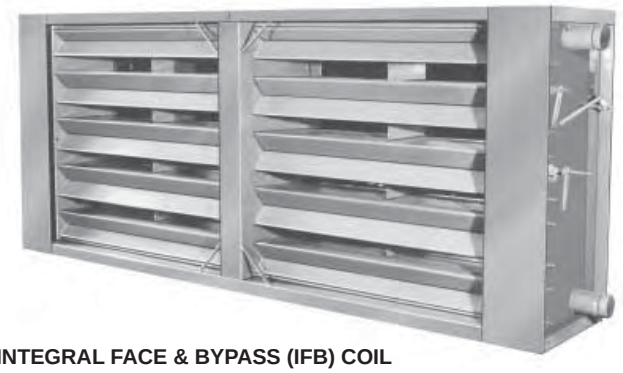
Heating Coils – Integral face and bypass

Integral face and bypass coils have alternating channels of heat transfer surface and bypass zones. The air flow is directed over the heat transfer surface or through the by-pass zone by modulating dampers that are integral with the coil construction.

Integral face and bypass coil (IFB/VIFB)

- Coils are available in the 'IC' segment
- Tubes either Vertical or Horizontal
- Coils for maximum freeze protection
- Hot water or Steam coils
- Multiple rows deep

Steam or Hot Water



INTEGRAL FACE & BYPASS (IFB) COIL

Notes & Options

Coil Style:
- IFB
- VIFB

Coil Type:
- Water (Glycol)
- Steam

Rows:
- 1,2,3,4

Connection:
- SCH 40 pipe

Thermostat:
- None
- Electric

Fin Material:
- Aluminum

Fin Spacing:
- A range of fins per inch available

Coil Casing:
- Galvanized

Heating Coils – Steam Distributing

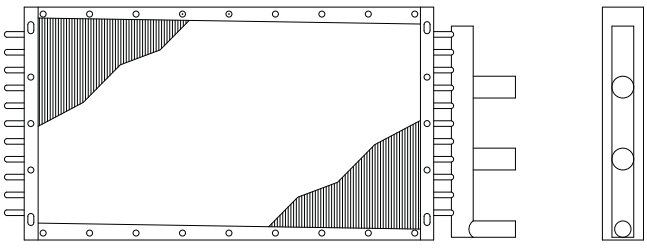
The construction of a Steam Distributing Coil is entirely different than that of a Standard Steam.

Everyplace that you see an outside tube or header, there is an inside tube and header that you can't see. Steam is distributed through these inside tubes and headers and slowly released to the outside tubes as the steam turns to condensate. The condensate then flows back down the outside tubes in the same direction that the entering steam comes from. The idea is that all the steam in the inside tubes keeps the condensate in the outside tubes from freezing when air passes across the coil at less than 32ºF. However, under exactly the correct conditions, even steam distributing coils can freeze.

Steam Distributing - 1" diameter tube

- Available in CC, VC, HC, MZ segments
- A vast range of fins per inch available
- Multiple tube wall thickness options

Steam



COIL OPTIONS

Typical Application of Air Handling Coils

Heating Coils

Heating coils can use steam or hot water to add heat to the air stream. In a cooling-only VAV system, the heating coil is generally placed in the 'preheat' position between the filters and cooling coil. The preheat coil can be omitted in this system if the minimum outside air requirement is low and would not result in a mixed air temperature below 50ºF to 55ºF.

Heating coil capacity is controlled by means of a modulating control valve in the water or steam piping. The control valve position is usually controlled by means of a thermostat in the supply air duct in sequence with the cooling coil control valve.

Cooling Coils

Cooling coils remove both sensible and latent heat from the mixed air and can use chilled water, chilled brine, or refrigerant as the cooling source. In the case of chilled water, the supply water temperature generally ranges from 42ºF to 50ºF, depending on the latent load to be removed. Brine or a solution of ethylene or propylene glycol in water is traditionally used at temperatures of 32ºF to 40ºF for applications in which piping is exposed to freezing temperatures. Control of the cooling coil capacity at the air-handling unit is achieved by means of a two-way 'throttling' or three-way 'mixing' control valve. In VAV systems, a supply duct thermostat is typically used to modulate the control valve so as to maintain a constant temperature of air leaving the unit, usually 55ºF to 60ºF.

When refrigerant is used as the cooling source, it enters the coil in liquid form from a condensing unit and provides cooling by a process called 'direct expansion'. The liquid refrigerant evaporates as the warmer air moves across the coil, removing heat from the air during the process. The evaporated refrigerant is then compressed in the condensing unit, which also houses the condensing coil where the heat is rejected to the outside. Control of the coil capacity is typically by means of a series of solenoid valves in the refrigerant liquid lines, which are energized to shut-off the flow of refrigerant to part of the coil. There are several problems with the application of VAV to a direct expansion (DX) coil which require the designer to take special precautions when considering this system. First, the balance point temperature for the DX coil will change as the air flow rate changes. Assuming constant coil capacity, reducing the CFM will reduce the suction temperature and pressure, making close control of air temperature difficult. In addition, compressor unloading at reduced load will cause step changes in capacity and suction temperature, which can cause hunting in the flow control loop. In short, the use of variable air flows with a DX coil requires careful consideration of the effect air flow changes make to the system. Balance point temperatures must be carefully considered.

Design Considerations

In order to insure predicted coil performance, air distribution must be uniform. There are two design checks for this:

1. '45 degree rule' – This rule states that the performance of the coil will not be affected as long as the diffusion angle from the most restrictive block-off to the finned portion of the coil is 45 degrees or less. This rule holds true unless there are unusual flow fields, caused by such components as upstream fans or mixing boxes where not applied properly.
2. 'Uniform pressure rule' – This rule states that the performance of the coil will not be affected as long as the maximum difference in upstream, downstream, and combined static pressure due to local velocity pressure at any one point on the coil compared to another point that does not exceed 10 percent of the pressure drop through the coil. The basis for this rule is that the flow rate through the coils at any one point is a function of the local upstream and downstream pressures, and if pressure differences are small, distribution will be uniform.

Literature Reference — See "DX Piping Guide" – Form 050.40-ES2

SOLUTION SEGMENT IDENTIFICATION

FAN SEGMENTS

- FS – Supply
  - Forward Curved
  - Airfoil
  - Industrial Airfoil
  - SWSI Plenum (Belt and Direct Drive)
- FR – Return
  - Forward Curved
  - Airfoil
  - Industrial Airfoil
  - SWSI Plenum (Belt and Direct Drive)
- FE – Exhaust
  - Forward Curved
  - Airfoil
  - Industrial Airfoil

COIL SEGMENTS

- CC – Cooling Coil
- HC – Heating Coil
- VC – Vertical Coil
- MZ - Multizone

HEAT SEGMENTS

- IC – Integral Face & Bypass Coil
- IG – Indirect Gas Fired Furnace
- EH – Electric Heater

ENERGY RECOVERY

- ER – Energy Recovery

FILTER SEGMENTS

- FF – Flat Filter (2” or 4”)
- AF – Angle Filter (2” & 4”)
- RF – High Efficiency Filter
  - Rigid Filter (12”)
  - Bag Filter (21”)
  - Mini-Pleat Filter (4”)
- HF – HEPA Filter

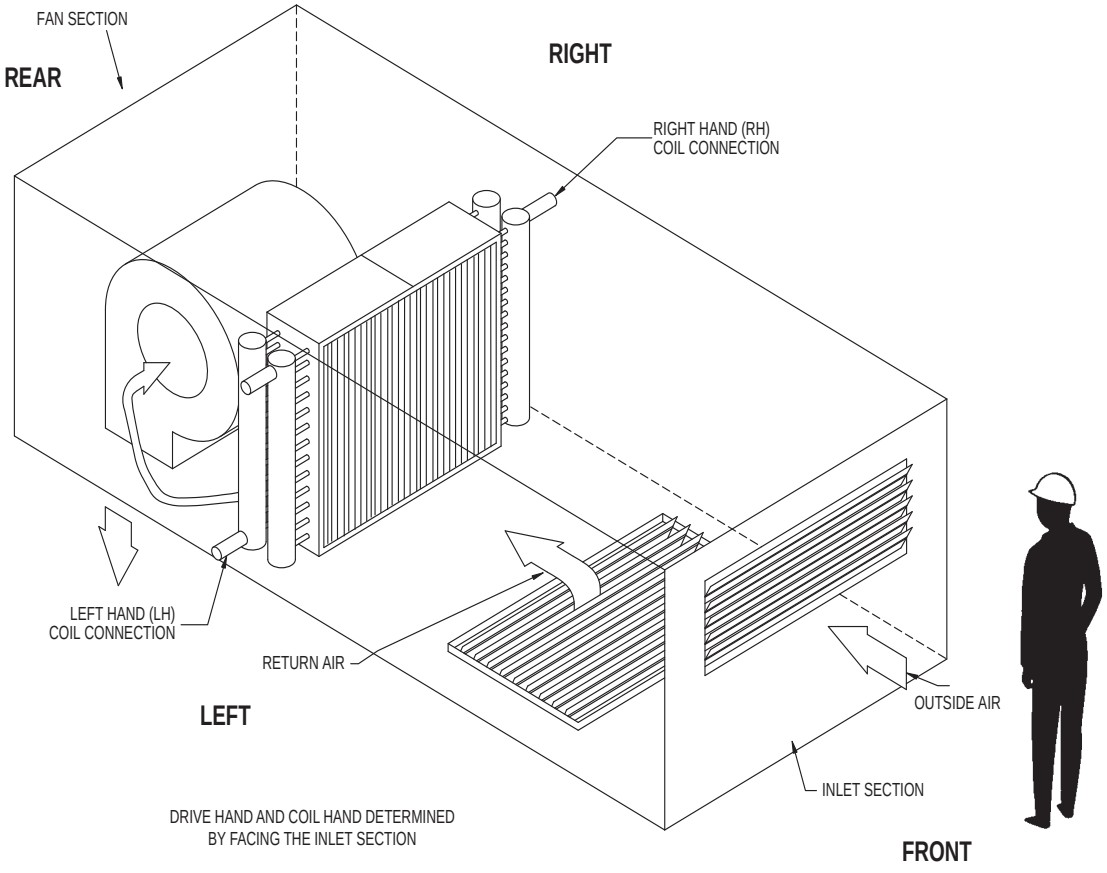
INLET SEGMENTS

- MB – Mixing Box
- FM – Filter/Mixing Box
- EF – Filter/Economizer
- EE – Economizer
- IP – Inlet Plenum
- VE – Vertical Economizer
- VF – Vertical Filter/Economizer

ACCESSORY SEGMENTS

- VP – Vertical Plenum
- DP – Discharge Plenum
- TN – Turning Plenum
- DI – Diffuser
- XA – Access segment
- AB- Air Blender
- EB – External Bypass
- IB – Internal Bypass
- FD – Face Damper
- AT – Attenuator
- HM - Humidifier
- UV - UVC Lamps

Unit & Coil Hand Identification



SINGLE FAN SEGMENT – FS, FR AND FE

Fan Applications

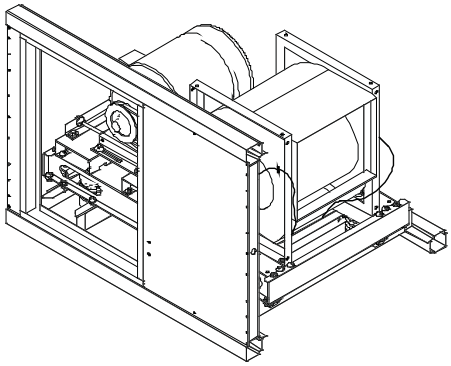
Fan segments are available as supply, return and or exhaust applications. Unit configurations have a segment option of utilizing a single fan or a dual fan arrangement. Isolation consists of 1" or 2" springs with a seismic snubber option. Thrust restraints and OSHA belt guards are available as required.

Double-width/Double-inlet (DWDI)
- Forward Curve or Airfoil centrifugal
- Belt Driven

Single-width/Single-inlet (SWSI)
- Airfoil plenum
- Belt Drive or Direct Drive

In most fan systems a segment with a single fan is adequate for the required system design and rating. Methods of control can vary and may include dampers or variable speed drives. Also included in a single fan design may be the allowance for future expansions.

Bearing options for fans with lubricating bearings: *(refer to Notes & Options)*
- Extended Lube Line
- External Lube Line



In some situations, there may be a need for a system design using multiple fans in a cabinet. The following are some reasons to consider a dual fan arrangement:

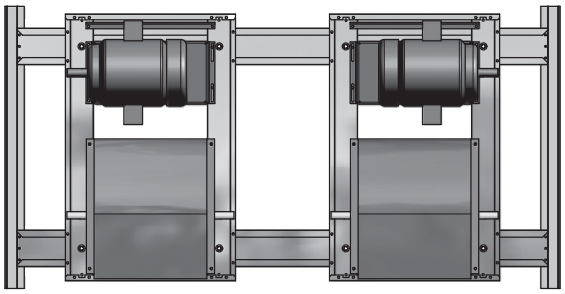
Dual Fan Considerations

1. One fan may be too large and not fit into the desired space, or it may weigh too much if supported on upper levels.
2. The required operating range of the system may necessitate multiple fans instead of one large fan controlled over a wide operating range.
3. Multiple fans for capacity control may be more economical if cost of operation is critical, especially at very low flow rates for long time intervals.
4. Critical systems are often equipped with redundant or back-up fans in case of a fire or accident or some other emergency that requires a sudden increase in flow. Redundant fans are also used to eliminate downtime during fan maintenance.
5. Some systems for process applications may require pressures that are greater than a single fan can produce or when noise may be a special concern.

Dual Fan Applications

Solution dual fan application methods include 50/50 where both fans operate together to share the load equally or 100/100 where only one fan at a time is in operation.

- In a 50/50 application, the failure of one fan will result in a condition where the other fan will continue to operate. The single fan will provide partial load capabilities
- In a 100/100 application, the failure of one fan will result in the operation of the other (standby) fan to provide full capacity



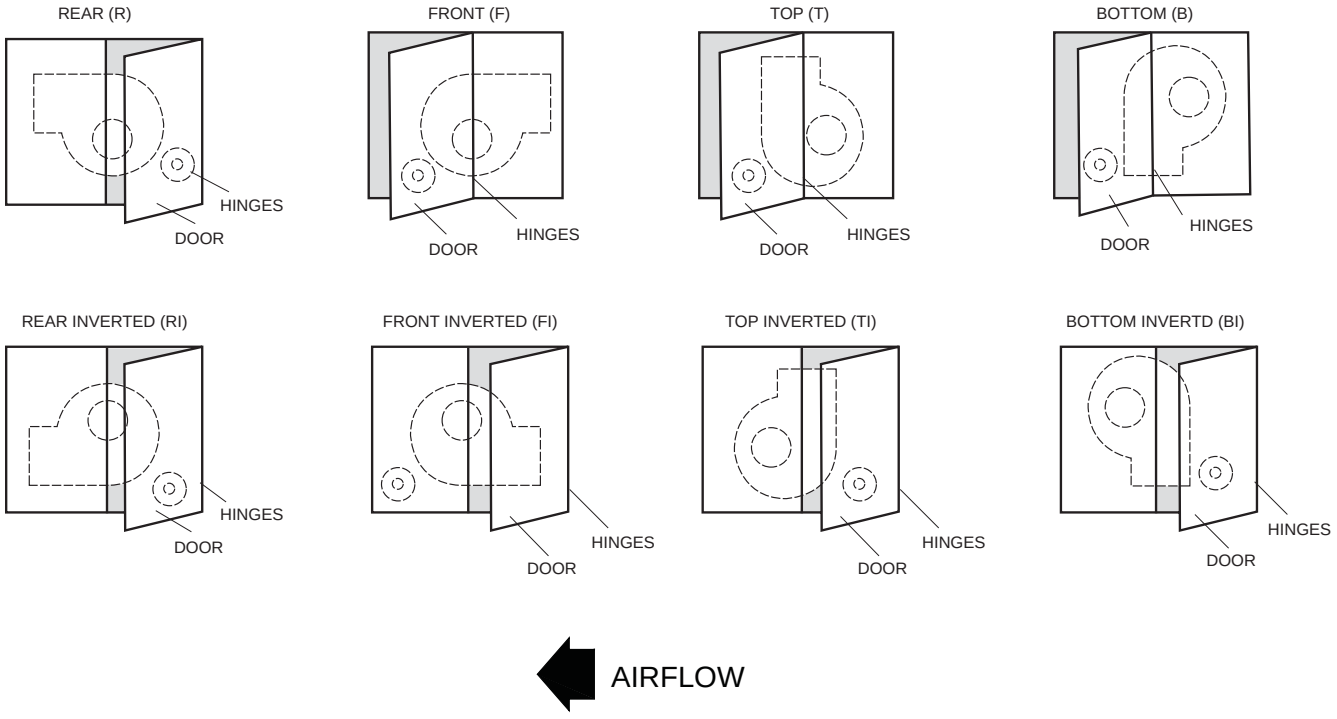
Literature Reference — see Application Guide *'AHU Dual Fan Options'* - Form 102.20-AG17

Door and Discharge Locations

Fan and fan motor may be oriented in the fan segment. Consideration must be given to which orientation is used where. Upstream/downstream usage follow.

Where Doors are used:
Rear/rear-inverted discharge – Upstream
Top/bottom discharge – Downstream

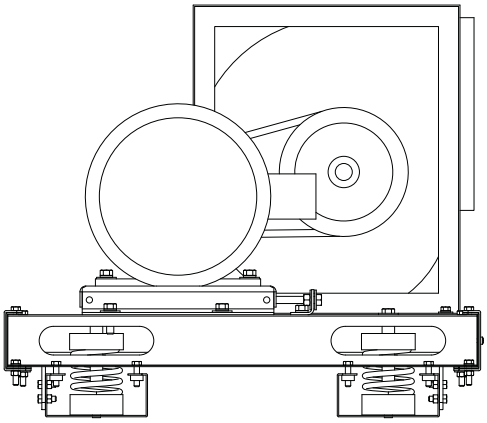
Front/front inverted discharge – Downstream
Top-inverted/bottom-inverted discharge – Upstream



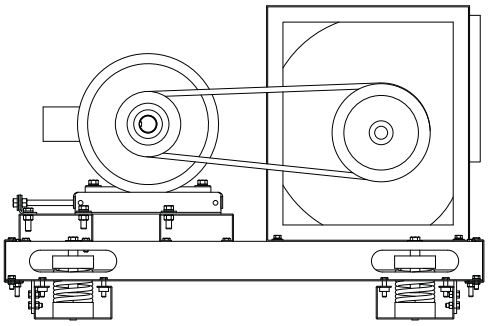
SINGLE FAN SEGMENT – FS, FR AND FE

Double-width/Double-inlet (DWDI) Options – Belt Drive

Fan and fan motor may be oriented in the fan segments as shown. Consideration must be given to which orientation is used where. Upstream/downstream images shown below.



Motor Beside



Motor Behind

Notes & Options (DWDI)

1. If a discharge plenum is immediately downstream of a fan section and the discharge plenum has a top discharge, the fan section will be rear inverted discharge.
2. If the discharge plenum has a rear, side or bottom discharge, the fan will be rear discharge.
3. When a diffuser is ordered immediately downstream of a fan section, the fan will be rear or rear inverted discharge.
4. Door width is sized to remove max HP motor with connection box removed.

NOTE: Doors follow motor location. See door locations illustration on page 23.

Fan type available

- Forward Curve centrifugal
- Airfoil centrifugal

Class I (S) construction

- Permanently sealed bearings
- Fan sizes: 7x7 thru 18x18 (Forward Curve)

Class 1 Construction

- Lubricating bearings
- Fan sizes: 20x15 thru 40x40

Class II construction

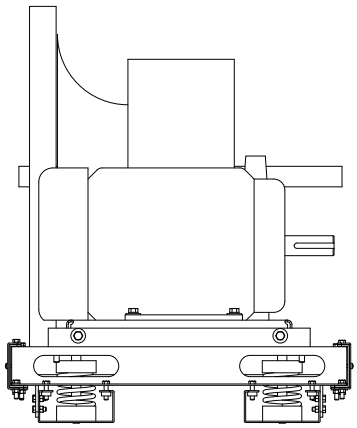
- Lubricating bearings
- Fan sizes: 7x7 thru 40x40

Thrust restraints are optional for rear and front discharge airfoil fans only.

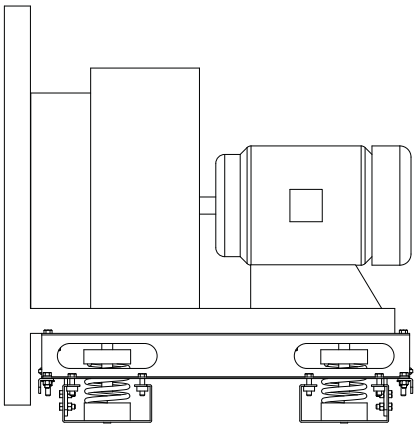
- Not available for FC fans.
- Required for AF with TSP over 6”

Single-width/Single-inlet (SWSI) Options

Fan and fan motor may be oriented in the fan segments as shown. Consideration must be given to which orientation is used where. Upstream/downstream images shown below.



Belt Drive



Direct Drive

Notes & Options (SWSI)

1. The plenum fan segments can accommodate multiple duct outlets, thus reducing the amount of field duct work and transitions.
2. When any filter segment (EF, FM, FF, AF, RF, or HF) or coil segment (CC or HC) is located upstream of a FS-SWSI, FR-SWSI or FE-SWSI, sufficient transition length will be required between the FS segment and the filter segment.
3. Fan discharge locations - rear, front, bottom, top, left and right.
4. Single Width, Single-Inlet (SWSI) air foil plenum fans are available as Class I, II & III. (with lubricating bearings)
5. Thrust restraints are required with TSP over 3”.

DUAL FAN SEGMENT – FS, FR AND FE

Double-width/Double-inlet (DWDI) Options – Belt Drive

Fan type available:

- Forward Curve centrifugal
- Airfoil centrifugal

Class I (S) construction

- Fan sizes: 7x7 thru 18x18 (Forward Curve)

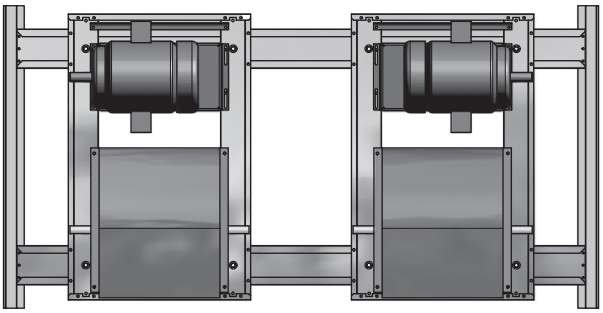
Class 1 construction

- Fan sizes: 20x15 thru 22x22

Class II construction

- Fan sizes: 7x7 thru 22x22

DWDI motor location – Behind only



Motor Behind

Notes & Options

Access doors are provided on both sides of the segment.

- Allow sufficient access-to and clearance-around the segment for motor removal from either side.

Separation Panel Option

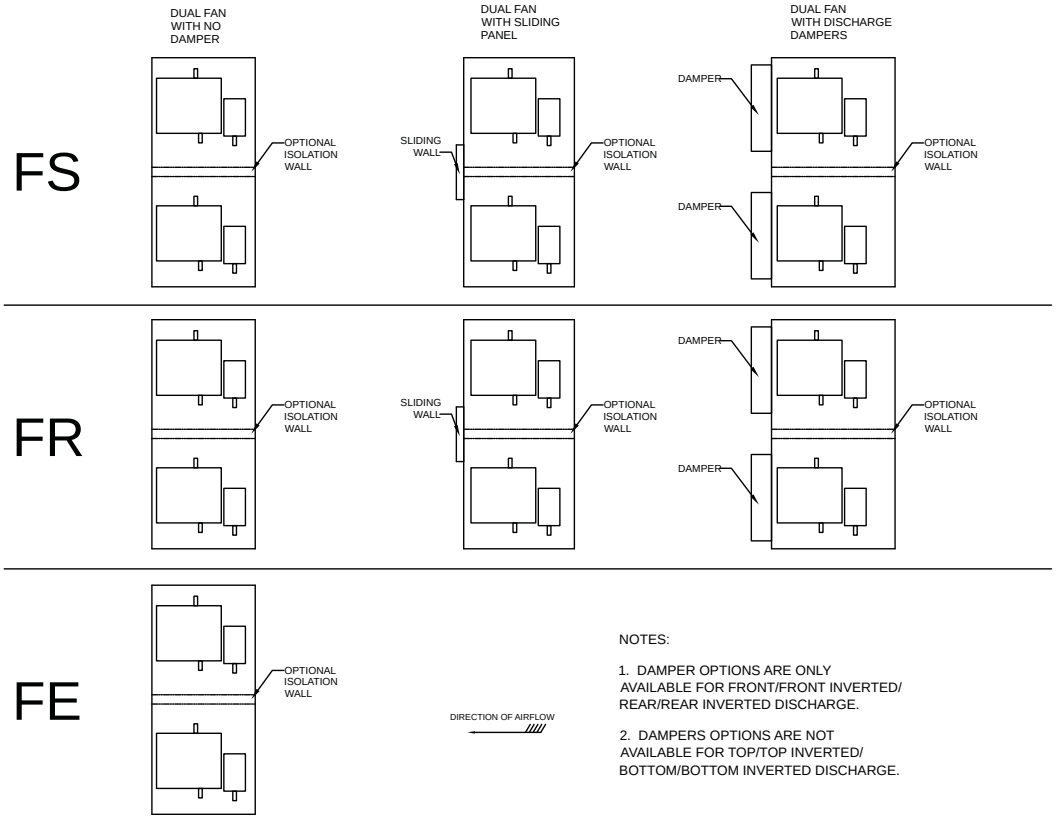
- Optional safeguard when servicing requires that the system be in a running status. A separation panel is positioned between the fans.

Flow Isolation Options

- Optional isolation method to prevent air from an energized fan going back through a fan that is not energized.
- DWDI option is mounted on fan discharge.
- *Note:* Not available with fan exhaust (FE)
- Option is required with 100 %/100 % method.

Options include (depending on type of fan):

1. Manual sliding panel
2. Back-draft damper with counter balance
3. Mechanical Control damper


DUAL FAN WITH NO DAMPER
DUAL FAN WITH SLIDING PANEL
DUAL FAN WITH DISCHARGE DAMPERS
FS
FR
FE
OPTIONAL ISOLATION WALL
SLIDING WALL
DAMPER
DIRECTION OF AIRFLOW
NOTES:
1. DAMPER OPTIONS ARE ONLY AVAILABLE FOR FRONT/FRONT INVERTED/ REAR/REAR INVERTED DISCHARGE.
2. DAMPERS OPTIONS ARE NOT AVAILABLE FOR TOP/TOP INVERTED/ BOTTOM/BOTTOM INVERTED DISCHARGE.

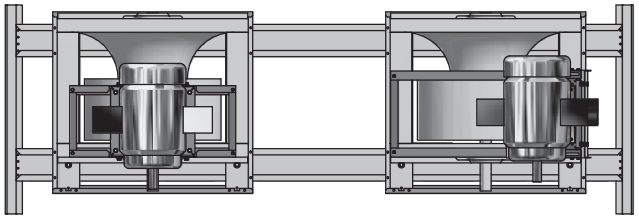
Single-width/Single-inlet (SWSI) Options – Belt-Drive or Direct Drive

Fan type available:

- Standard Airfoil (AF) 10" – 30"
- *Industrial Airfoil (AF) 12" – 30"
- Class I, II, *III

SWSI motor location:

- 10" to 16" fans - behind motor only
- 18" to 30" fans -top motor only
- Fans with top motor location will require thrust restraint



Notes & Options

Access doors are provided on both sides of the segment.

- Allow sufficient access-to and clearance-around the segment for motor removal from either side.

Separation Panel Option

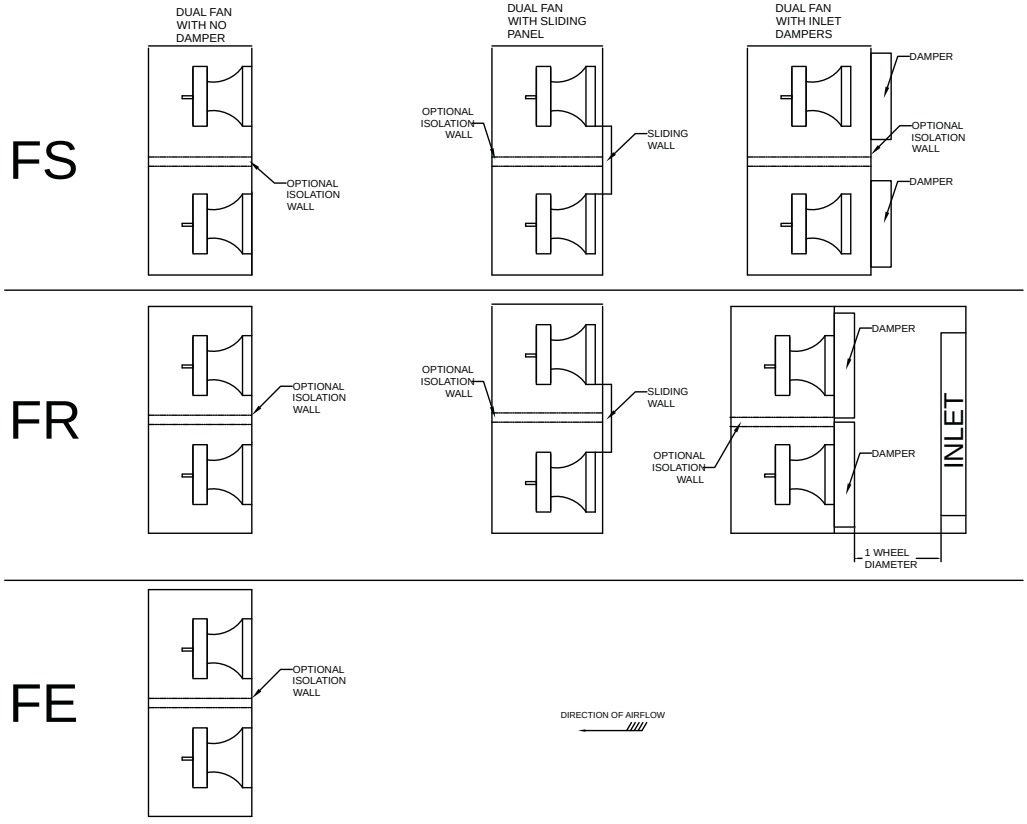
- Optional safeguard when servicing requires that the system be in a running status. A separation panel is positioned between the fans.

Flow Isolation Options

- Optional isolation method to prevent air from an energized fan going back through a fan that is not energized.
- SWSI option is mounted on fan inlet.
- *Note:* Not available with fan exhaust (FE)
- Option is required with 100 %/100 % method.

Options include (depending on type of fan):

1. Manual sliding panel
2. Back-draft damper with counter balance
3. Mechanical Control damper



FAN SEGMENT – FS, FR AND FE

SWSI Plenum vs. DWDI Housed Fan Application

SWSI Plenum airfoil fans offer superior performance for many applications. Typical concerns with fan performance are efficiency, noise, and air velocity profile through components. Plenum fans offer advantages for all three concerns. Additionally, these fans provide flexibility with outlet configurations, reduced mechanical space footprint, and the benefit of direct-drive.

Efficiency:

DWDI housed fans use a scroll to increase their efficiency. However, optimizing this fan requires a process referred to as “static regain”. Housed fans are tested with an outlet duct of 2.5 to 3.5 times the wheel diameter in length. This outlet duct allows the “static regain” process, where velocity pressure is converted to static pressure. Housed fans applied without this outlet duct will require a system effect factor (SEF) which decreases the fan efficiency. Housed fans in blow-through positions will also require an air diffuser which decreases the efficiency further. *The combination of these two system effects brings even the best housed DWDI airfoil fan efficiency to, or below that, of the SWSI plenum fan, thereby eliminating the benefit of the fan scroll.*

Noise:

Plenum fans have the benefit of effectively utilizing the entire unit as the fan housing, which offers superior attenuation. The same factors that decrease the housed fan’s efficiency discussed above also increase the noise level of the housed fan. Also, since the SWSI plenum fan has no scroll, typically there is room within the air handling unit for a larger wheel (33” SWSI plenum vs. 27” DWDI housed, for example), which generally produces better sound characteristics. For design pressures at or below 6.00 in. W.C., it is very common to see supply air sound power levels lower when using a SWSI plenum airfoil fan instead of the DWDI housed airfoil fan. Additionally, perforated liners may be used in plenum fan sections for greater attenuation.

Velocity Profile:

Due to the relatively small outlet/blast area of housed DWDI fans, an air diffuser must be applied to the discharge of the fan to obtain an acceptable velocity profile through the next component. Air diffusers add static pressure which decreases fan efficiency and increases fan noise levels. *SWSI plenum fans positively pressurize the entire cabinet, they do not require a diffuser with its associated performance losses*.

Outlet Flexibility:

SWSI Plenum fans serve to pressure the entire fan plenum, *allowing for multiple duct take-off from the AHU*. Additionally, these openings can be tailored to match virtually any duct configuration, be it rectangular or round / flat-oval with bellmouth fittings for improved acoustic and optimized pressure drop performance.

Mechanical Space Optimization:

A housed DWDI fan requires a straight run of duct per AMCA guidelines at the outlet of the fan before elbows can be applied. This constraint imposes restrictions on duct layout and mechanical space design which generally increase overall footprint requirements. The ducted take-offs from pressurized plenums, as in the case of a *SWSI plenum fan, does not have a requirement for a straight run and affords greater flexibility to the architect and engineer in ductwork design*.

Direct-Drive Benefit:

Specialty housed DWDI fans can be used in direct-drive arrangements, where the fan wheel is directly mounted onto the motor shaft, most-typically, housed fans are driven by a belt and sheave system. Belt-drive systems typically allow for 3-5% of efficiency loss and impose maintenance requirements not present in direct-drive systems. Additionally, belts wear and give off debris in the form of belt dust. Anymore, discerning engineer’s apply direct-driven SWSI plenum fans with VFD’s for efficient variable air volume duty and trouble-free maintenance.

Fan Motor Control Methods

Motor control options can be explained as any one of the 3 items described below.

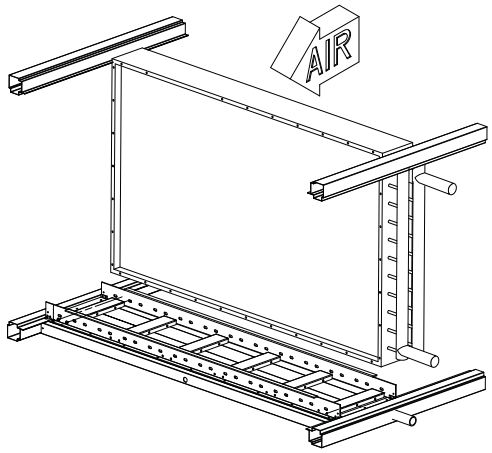
Disconnect This is a device for the source of power (line voltage as provided through the building electrical utility) from the controlled device (motor).	• Low Cost • Constant Volume • No BAS control needed
Across-the-line Starter Motor Controller will provide a start / stop operation of a motor. An integral disconnect (shall incorporate a "lockout/tag-out" system) shall provide disconnecting of "line side" power from the electrical utility system. The motor controller will also contain the proper short circuit and thermal overload protection for the motor that it is controlling.	• Higher Cost • Constant Volume • Start/Stop controlled remotely • Thermal Overload Protection • Under/over Voltage Relay • Disconnect Option - Fused only Indoor Enclosure - NEMA 3R Indoor Voltages - 200, 208, 230, 380, 460, 575 Outdoor Enclosure - NEMA 3R Outdoor Voltages - 200, 208, 230, 380, 460, 575
Variable Frequency Drive (VFD) The Air-Modulator type controller varies speed of the motor by pulse width modulation of the alternating current waveform. An integral disconnect (incorporates a "lockout/tag-out" system) provides disconnecting of "line side" power from the electrical utility system. This motor controller will also contain the proper short circuit and thermal overload protection for the motor that it is controlling.	• Highest Cost • Variable Volume • Start/Stop controlled remotely • Integrated basic unitary controller (can also integrate with BAS) • Comprehensive Protection • Disconnect Options -Fused, Non-fused, or None Indoor Enclosure - NEMA 1 Voltages - 200, 208, 230, 460 Outdoor Enclosure - NEMA 3R Outdoor Voltages - 200, 208, 230, 380, 460, 575

Literature Reference — See Engineering Guide – *'Air Modulators'* – Form 100.42-EG1

COIL SEGMENT – CC, HC AND VC

Cooling Coil – (CC)

When cooling 100% OA there are precautions required. Summer design conditions are such that when air is cooled down to normal coil leaving temperatures, there is a considerable amount of condensate generated. Many applications suggest cooling coils should be selected for an air velocity under 500 FPM. If the unit is selected as a 100% OA application, the drainage area for larger face area coils will be increased to properly compensate for the probable condensate.



Notes & Options

Coils

- A combination of Water and DX coils in the same segment requires all coils to be of the same tube diameter.
- Multiple Water coils configured in the same segment must be of the same tube diameter.
- Steam coils may be configured with 5/8” tube coils. A spacer must be used between a steam coil and any water coil or DX coil.

Headers

- Usual header location is drive side.
- All headers in the same segment must exit the unit on the same side.

Door

- Usual door location is drive side
- With pipe chase, the door is always opposite the pipe chase

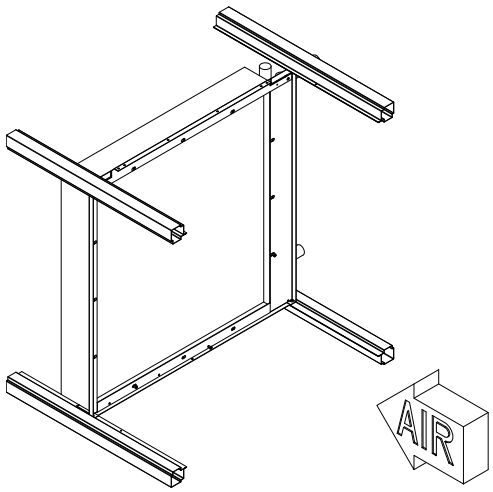
IAQ drain pans material options:

Liner – Galvanized or Stainless Steel

Heating Coil – (HC)

When heating only is required the heating coil segment is an excellent minimally sized housing which shall accommodate a single heating coil. Coils are offered with left or right hand connections. Coils will be individually mounted and easily removable.

Coil segment panels (side panels and top panel) shall be easily removable to allow for removal and replacement of coils, without affecting the structural integrity of the unit.



Notes & Options

Coils

- Only hot water and steam coils are available in the HC segment.
- Only one coil (hot water or steam) is permitted per segment.

Headers

- Usual header location is on the drive side.

Doors

- Doors are not available.

Drain pans

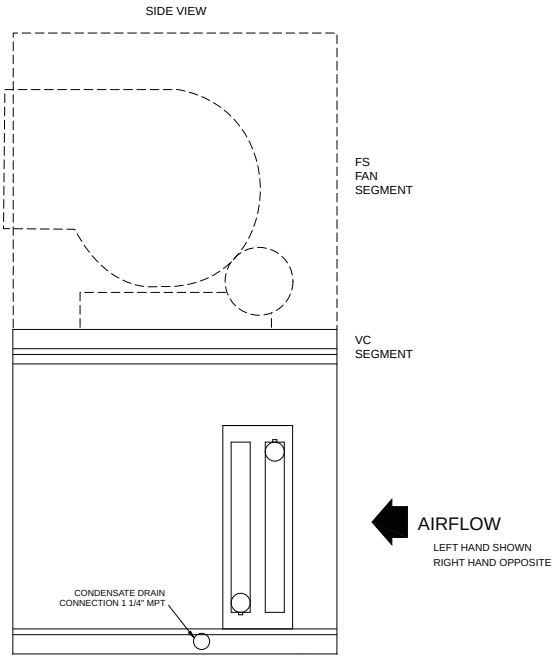
- Auxiliary drain pan is optional.
- Usual drain location is header side.
- The drain is always opposite the pipe chase.

Literature Reference — See Service Guide – *‘Field Assembly ad Disassembly Indoor/Outdoor’* – Form 102.20-FA1 & Installation Manual Form 102.20-NOM1

Vertical Coil – (VC)

This segment shall provide for a 90-degree change in airflow direction from horizontal to vertical, after passing air through the coil space.

Coils are configured for horizontal air flow to minimize segment length. Drains pans are extended to assure complete condensate drainage and coil access. Coil segment panels (side panels) shall be easily removable to allow for removal and replacement of coils, without affecting the structural integrity of the unit.



Notes & Options

Coils

- All coils located in the same coil segment must have the same coil hand.
- Multiple Water coils configured in the same segment must be of the same tube diameter.
- A combination of Water and DX coils in the same segment requires all coils to be of the same tube diameter.
- The steam coil is available for use in the VC segment. Steam coils may be configured with 5/8” tube coils. A spacer must be used between a steam coil and any water coil or DX coil.

Headers

- Usual header location is on the drive side.
- All headers in the same segment must exit the unit on the same side.

Doors

- Usual door location is on the drive side.
- Doors are always last in the air stream of the segment
- With pipe chase, the door is always opposite the pipe chase

Drain pans

- IAQ drain pan liner - Galvanized or Stainless Steel
- Usual drain location is on header side
- With pipe chase, the drain is always opposite the pipe chase

STAGGERED COIL OPTION – CC, HC, AND VC

Staggered Coil configurations are available as an option for both the indoor and outdoor Solution® units. *Angled Wall* or *Back-to-Back* configurations are available in both heating and cooling coil segments.

Angle Wall

Staggered coil design increases coil face area and allows increased CFM without having to increase cabinet size.

Notes & Options

Coils

- A staggered coil can not be combined with a non-staggered coil in the same segment.
- Each coil bank will be located over a drain pan.
- Not available as a reduced face coil option.

Controls

- Optional control valve and valve jack (manifolded together external of unit).

Drain pans

- Pan connection hand follows coil hand except for outside units where the drain connection is opposite the coil hand.
- If coil connections are on both sides, the drain pan connection follows the ”primary” side of the unit.

Headers

- Coil connections can be on the same side or opposite sides.
- Optional factory extended piping connections for each coil to the exterior of the unit.
- Optional insulation for extended piping.
- Extended piping does not apply to DX coils.

Back-to-Back

Staggered coil design is specifically for a reduced coil pull distance and for opposite side connections. Two shorter coils will be used in place of one longer coil.

Notes & Options

Coils

- A staggered coil can not be combined with a non-staggered coil in the same segment.
- Not available as a reduced face coil option.

Drain pans

- The drain pan connection follows the ”primary” side of the unit.

Headers

- Coil connections can be on the same side or opposite sides.

Multi-zone Segment – (MZ)

MZ heating and air conditioning units offer design and application advantages over various smaller single zone units. The Solution unit is designed to carry on that tradition by including a MZ segment into the design of the unit.

MZ and Dual Deck air-handling units can be configured for heating and cooling, or cooling and ventilation, or ventilation and heating applications.

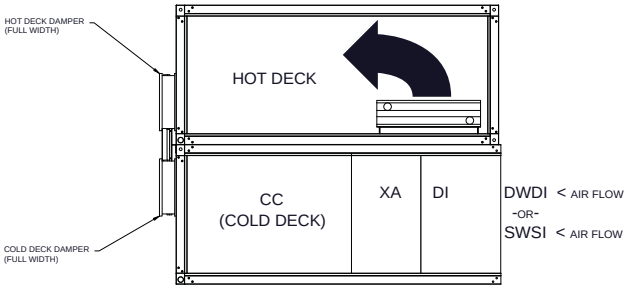
Rear or Top discharge MZ configurations:

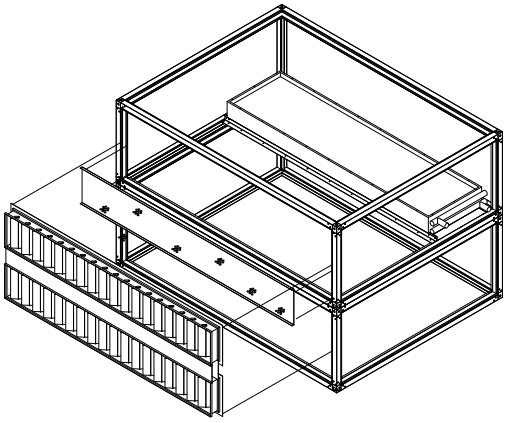
- The bottom tier is the cold deck and contains a diffuser and a cooling coil space.
- The top tier is the hot deck and contains a heating coil mounted horizontally at the upstream side of the hot deck.

Air enters the diffuser then splits into two streams.

- One stream turns up through the hot deck coil and exits the rear or top through the hot deck damper.
- The other stream continues horizontally through the cooling coil and exits the rear or top through the cold deck damper.

The MZ unit is optionally available less the zone dampers for use on dual duct or other blow-thru systems. If a hot deck opening is not required, it may be blanked-off in the field.





Notes & Options

The MZ segment is for indoor applications only and will be the last segment in air-stream.

Air pressure drop balance plates shall be used to equalize pressure drop across the hot and cold deck coils when required.

Door is optional for cold deck.

Discharge options:

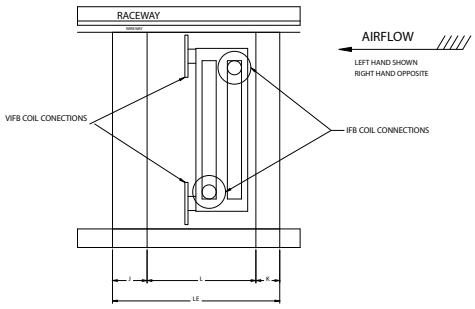
- Top with damper or without damper
- Rear with damper or without damper

Literature Reference — See Application Guide – *'Multizone Application of Solution Units'* – Form 102.20-AG12

HEATING SEGMENTS

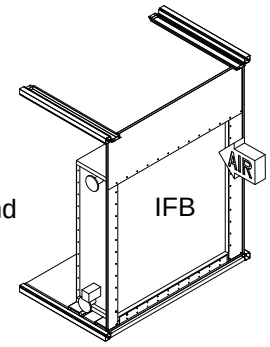
Integral Face & Bypass – (IC)

The Integral Face & Bypass coil controls air temperature while full steam pressure or water flow is maintained in the coil at all times. The temperature of the discharge air is controlled by proportioning the entering air through the multiple heating and by pass channels.



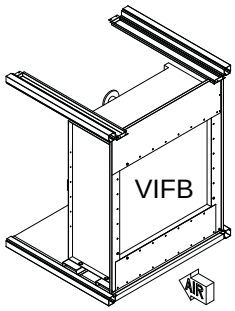
Applications ideally suited for:

1. Make-up Air
2. Combustion Air Make-up
3. Penthouse units
4. Air conditioning preheat and heating/ventilating units.



Features & Benefits:

- Maximum freeze protection
- Constant volume
- Minimum temperature override
- Minimum stratification
- Accurate temperature control



Notes & Options

1. Coil connections must be located opposite the access door.
2. All piping to be supplied by field, coil connections are internal from factory.
3. Optional pipe chase with outdoor units
4. Pipe chase is not intended for trapping or piping, but for the connections only.

Headers:

Usual header location is on the drive side. Header location must be opposite the access door.

Coils:

Only hot water and steam applications are available for this segment.

Doors:

Access doors and viewing ports must be located in adjacent segments.

A door is required in the immediate downstream segment from the IC segment.

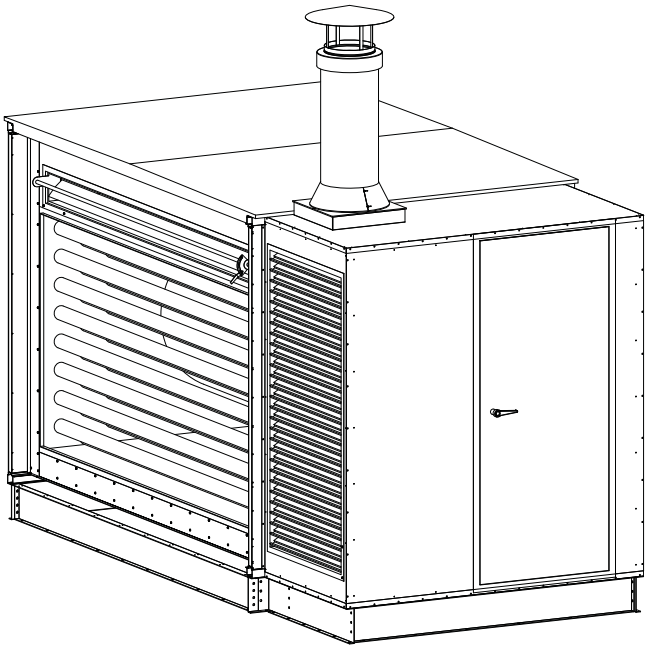
Auxiliary Drain pans:

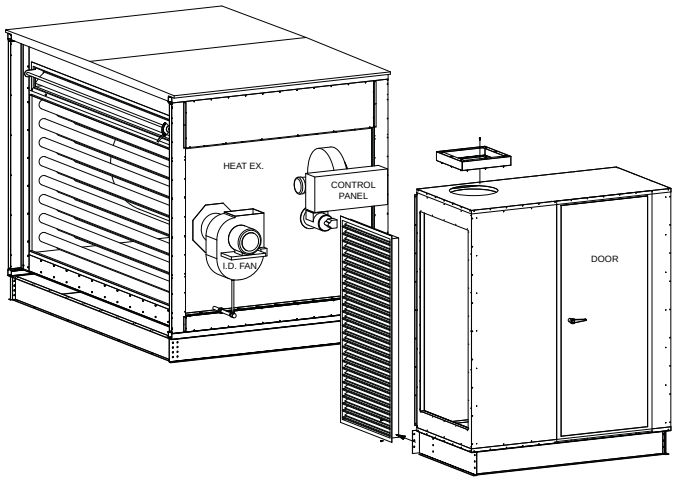
An auxiliary drain pan is optional.

Usual drain location:

- With pipe chase, the drain is always opposite the pipe chase
- IFB on header side
- VIFB on left side of the unit

Indirect Gas-Fired Furnace – (IG)





Notes & Options

The IG segment must be positive pressure. (Fan segment is not allowed downstream of the IG Segment.)

Furnaces in VAV applications are designed to be used only with 100% supply fan airflow.

- Use of furnace in reduced airflow operation may result in serious damage to equipment and may be hazardous.
- Indirect Gas-Fired Furnace Maximum Temperature rise = 90F
- Indirect Gas-Fired Furnace Maximum A.P.D. = 2.00” W.C.
- The Maximum Temperature at the IG segment discharge = 190F

Furnace includes a series stainless steel primary heat exchanger. A secondary stainless steel heat exchanger is also included.

- An access door is required upstream of any IG segment.
- Gas pipe train options are available

The IG segment pipe chase is a single pipe chase that covers only the IG segment.

- The pipe chase is not intended for trapping or piping, but for the connections only.
- Pipe chase enclosure is optional for indoor units and required for Outdoor units.

HEATING SEGMENTS

Turndown Examples and Guidelines – (IG)

Description

Indirect Fired Gas Heater section consists of the stainless steel primary and secondary heat exchanger with the power burner design. The basic design allows the power burner to inject the correct ratio of air and gas into the primary heat exchanger where the main combustion occurs. The heated products of combustion then pass through the multiple secondary tubes heating each tube for maximum heat transfer. The products of combustion then pass to the inducer draft fan and through the flue. The air is heated by passing around the primary and secondary tubes for optimal heat transfer. The heater is designed for 80% efficiency.

- The furnace comes wired with all necessary safety controls and valves installed.
- The controls vary based on the BTU level and Insurance Requirements selected.
- These units are designed to handle Natural Gas as a standard.
- The gas pressure available at the unit needs to be considered when ordering the equipment.

Equations:

- BTU Output Required = CFM x 1.08 x Temperature Rise Required
- BTU Input = BTU Output ÷ .80

The Solution furnaces are available with burner firing arrangements:

- 3-1 MODULATION: The burner will modulate for 100% - 33% of full fire
- 10-1 MODULATION: The burner will modulate from 100% - 10% of full fire
- 25-1 MODULATION: The burner will modulate from 100% - 4% of full fire

Choosing Considerations

When choosing the proper turn down three issues should be considered.

1. Greater modulation provides improved temperature control. If the furnace is modulated to its minimum fire position, and controls determine there is too much furnace capacity, then the furnace is staged on and off, on carefully chosen time delays, to satisfy the light load heating requirements. The 3-1 option is generally sufficient particularly if design temperature rise does not exceed 30-40 degrees.
2. The greater the range of modulation the greater the cost.
3. Experience requires that a furnace should not turn down to a temperature rise less than 5-8 degrees.

Greater modulation decreases the flue stack temperature at low fire, increases the amount of condensation, and can decrease the life of the heat exchanger even though all Solution furnaces utilizes a stainless steel primary and stainless steel secondary heat exchanger tubes along with condensate drains.

The condensate line must be adequately sized, trapped, along with drainage of the condensate per local code.

Literature Reference — See Installation Operation Manual – Form 102.20-NOM1

Electric Heat – (EH)

The EH segment can be installed in either a draw through or blow through arrangement.

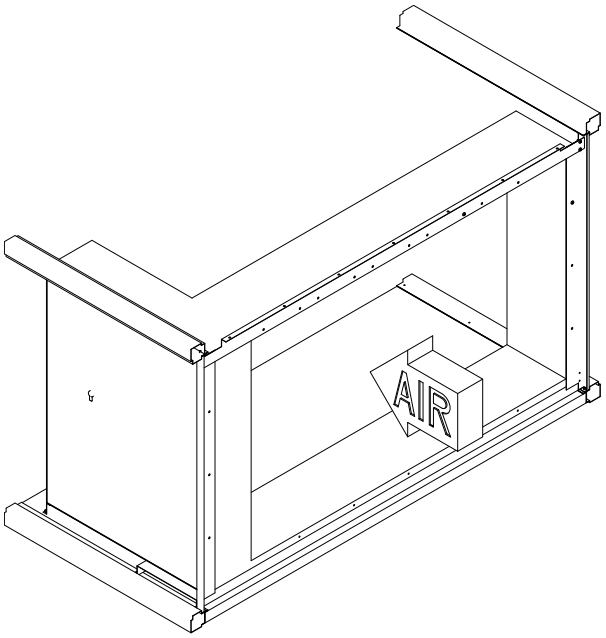
Remote Mounted terminal panels

- An electric heat control panel may be selected as a remote panel.
- In this case the panel will be shipped separate to the customer for field installation.

An optional wide access door may be ordered on the opposite side of the electric heater control panel.

An SCR Controller is available on all heaters with a height dimension greater than 26.5”.

$$\text{Delta T} = \frac{\text{kW x 3160}}{\text{CFM}}$$



Notes & Options

- Electric heaters are of “open coil” construction, with 80% nickel, 20% chromium coil elements machine crimped to stainless steel terminals and amply supported on ceramic bushing isolators. Open coil heaters are furnished with a disk-type, automatic reset thermal cutout for primary over-temperature protection. Heaters are also being furnished with disk-type, load-carrying manual reset thermal cutouts, factory wired in series with heater stages for secondary protection.
- Heaters are rated for the voltage, phase and number of heating stages indicated in the schedule. All three-phase heaters will have equal, balanced, three-phase stages.
- Finned tubular construction - optional
- All internal wiring shall be stranded copper with 105°C minimum insulation and shall be terminated in crimped connectors or box lugs.
- Power and control terminal blocks shall be provided and clearly marked for all field wiring and shall be sized for installation of 75°C copper wire rated in accordance with NEC Table 310-16, not more than three conductors in a conduit.
- Heaters shall be furnished with built-in fuses per NEC. Heaters with loads greater than 48 amps will be furnished with built-in fusing. Heaters shall be sub-circuited into a maximum of 48 amps per circuit. Low resistance single element fuses will be mounted in phenolic fuse blocks fitted with extra tension springs to assure cool connections. Fuses shall be sized at least 125% of the load.

HEATING SEGMENTS

Typical Applications

An electric heating system will use either an open wire element or an element encased in a sheathed ceramic material. For most applications either construction can be used, however, in applications with potentially high humidity (i.e.100% OA application), the encased element will have a longer life expectancy and is recommended.

Selection of the proper unit, heating load and temperature control system is dependent on the application of the unit.

1. Make-up Air Unit is used for heating 100% OA air to the indoor design temperature with a typical discharge temperature of 55-70° F.
2. Space Heating Unit is used for heating 100% RA from the conditioned space to make up for building heat loss.
3. Combination Make-up Air & Space Heating is used to heat OA & RA combined through a mixing box.

Optional Control Methods

1. Proportional step control – multi-staging control of circuits
2. SCR Controller – a time proportioning type controller that modulates the heater and supplies the exact amount of power to match the heat demand. Precision controlled from zero to 100% in direct response to the modulating thermostat signal system. 100% step-less and noise-less operation. *Note – SCR's are limited to a maximum KW. Multiple SCR's may be applied to larger heaters. Multiple SCR's do not imply full face control. See "Special Application Considerations".
3. Vernier Proportional Control – used on larger KW heaters where very close heat control is required. The system employs a combination of SCR and non-SCR steps. This is accomplished by satisfying most of the heat requirement through the non-SCR steps and then the last portion of the heat requirement is "fine-tuned" by the modulating SCR controller. The SCR step is nominally equal to the KW of a non-SCR step to provide an even transition between steps.

*Special Application Considerations:
(contact factory for special applications)

It is always important to ensure the proper control method so that the heater effectively treats the required amount of outdoor air regardless of temperature, without risking over heating and or tripping the low limit thermostat.

1. In applications where air flow varies and temperature ranges are extreme, the face area of the heater should be designed for full face simultaneous control, thus avoiding problems of air and temperature stratification. This is extremely relevant on heaters with large face areas. The full face control method, for a partial of fully active electric heat coil, eliminates the concern of air bypass through inactive circuits. Thus, almost any load split can be safely achieved.
2. With lower airflows under VFD control, one must assure there is even air flow across the face area of the heater. This may require special consideration of the air-inlet position and size, (i.e. inlet to be centered on the front of the unit).
    a. Instability in temperature can easily occur if the variation in the air flow characteristic is excessive. Large temperature variations can occur as specific stages and circuits are modulated on and off. In extreme cases, this instability can cascade and cause extreme over-heating on the complete heater face or in spots of the heater face due to low-air-flow augmented by unit inlet opening locations and distance.

Recommended Safety Control Options:

A fan relay and an airflow switch provide added protection for applications listed above.

- Fan relay provides the advantage of being a positive electrical interlock between the fan and the heater.
- Airflow switch is normally used to prevent a heater from operating unless air is flowing.

Minimum Air Flows

Electric heaters differ from steam or hot water coils in that the heat output is constant as long as the heater is energized. Therefore, sufficient air flow must be provided to prevent overheating and nuisance tripping of the thermal cutouts.

The minimum required velocity is determined from the graph on the basis of entering air temperature and watts per square foot of cross segmental heating coil area.

EXAMPLE:

Determine whether the minimum air velocity requirement is met for a 108 kW heater installed for an air handling unit operating at 18,000cfm at a maximum inlet temperature of 65°F.

1. Heating Coil Area = 33 sq. ft.
2. kW / sq ft. = 108 kW = 3.3 kW / sq. ft. 33 sq. ft.
3. Use top curve (below 80°F inlet air). Find 3.3 kW per square foot on the vertical axis.

   Read the minimum face velocity required, which in this case is 250 feet per minute (fpm).
4. AHU FV = 18,000 cfm = 545 fpm 33 sq. ft.

Since 545 FPM exceeds the minimum velocity requirement of 250 FPM, this installation is satisfactory for heater operation.

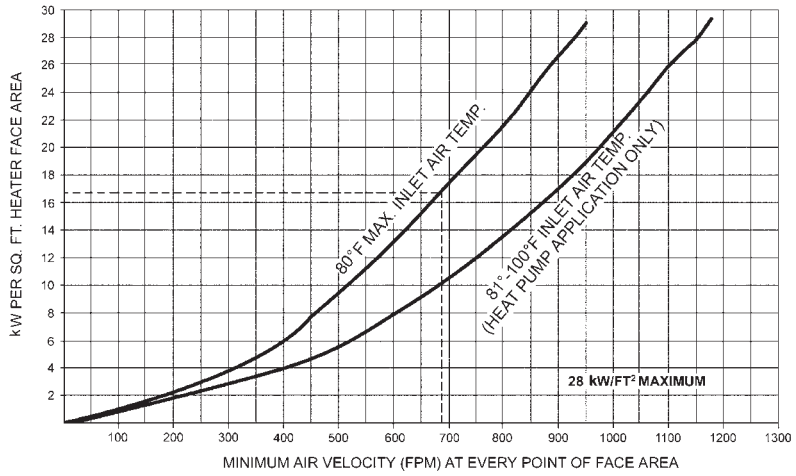
Equations: Use these formulas as rough guidelines for estimating purposes only:

EQUATION 1: MBH = kW x 3.412

EQUATION 2: $\blacktriangle T = \frac{kW \times 3160}{Scfm}$

EQUATION 3: Actual kW = Rated kW x $\frac{V\ actual}{V\ rated}$

EQUATION 4: Load Amps = $\frac{kW \times 1000}{V \times 1.732}$



Literature Reference — See Application Guide *'Electric Heaters for Air Handling Units'* – Form 102.20-AG4

ENERGY RECOVERY – ER

Energy Recovery

An HVAC system that utilizes energy recovery is more energy efficient, improves humidity control, and reduces peak demand charges.

Solution Energy Recovery wheels:

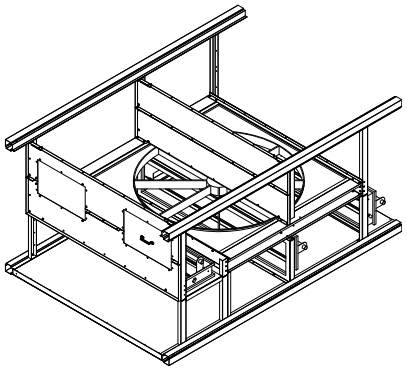
– Improve building HVAC system performance by efficiently preconditioning the outdoor air supply.

The ER segment transfers heat & humidity from adjacent exhaust air & outside air streams.

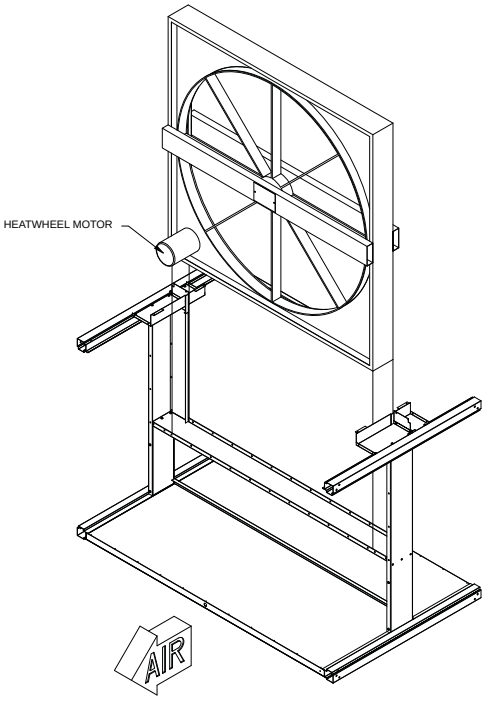
– Improves HVAC system efficiency up to 40%

– Improves de-humidification capacity up to 75%

Thermal performance is certified by the manufacturer in accordance with *ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and ARI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment*



Horizontal wheel segment



Vertical wheel segment

Notes & Options

ER has only one type of configuration – supply air fan draw-thru and exhaust air fan draw-thru for indoor and outdoor applications.

1. Indoor - Vertical wheel segment with stacked construction
   a. All doors are usually on drive side with two on top tier (both sides of wheel) and two on bottom tier (both sides of wheel).
2. Indoor and Outdoor - Horizontal wheel segment with single tier construction
   a. Outside Air inlet is located on both sides of segment
   b. Access door is usually on drive side for horizontal wheel segments.

Wheel control

- Damper control
- VFD

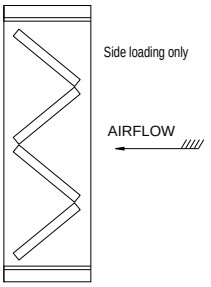
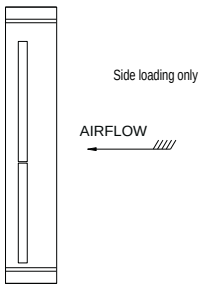
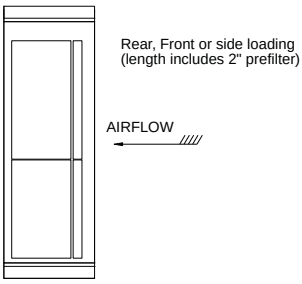
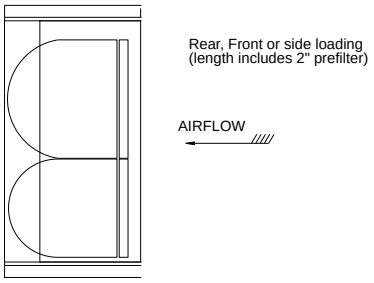
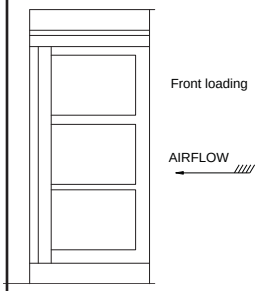
– Auxiliary drain pan – none

– Purge function – Optional

Literature Reference — See Application Guide “Energy Recovery Wheels” – Form 102.20-AG6

FILTER SEGMENTS – AF, FF, RF AND HF

Application and Options Table

 **AF - ANGLE FILTER**	Application: (AF) – Pre-filter side-load negative pressure configuration – Single stage filtration	Options: – Auxiliary Drain pan options – 2” & 4” Low Efficient media – 4” High Efficient media
 **FF - FLAT FILTER**	Application: (FF) – Pre-filter side-load negative pressure configuration – Single stage filtration	Options: – Auxiliary Drain pan – 2” & 4” media – Low Efficient media
 **RF - RIGID FILTER**	Application: (RF) – Pre filter negative pressure configurations: Side-load, front load and rear load – Final filter positive pressure configurations: Front-load (upstream access required) Rear-load (downstream access required) Side-load	Options: – 2-stage filtration. – Auxiliary Drain pan – 4” & 12” High Efficient Media (65%-95%)
 **RF - BAG FILTER**	Application: (Bag) – Pre filter negative pressure configurations: Side-load, front load and rear load – Final filter positive pressure configurations: Front-load (upstream access required) Rear-load (downstream access required) Side-load	Options: – 2-stage filtration. – Auxiliary Drain pan – High Efficient Media (65%-95%)
 **HF - HEPA FILTER**	Application: (HF) – Pre filter negative pressure configurations: Front-load (upstream access required) – Final filter positive pressure configurations: Front-load (upstream access required)	– Face velocity - maximum 500 fpm – Single stage filtration Options: – Auxiliary Drain-pan – Media efficiency 99.97% & 99.99%

Caution – Never place a blow-thru final filter segment directly downstream of a cooling coil with a saturated leaving air temperature. Once the relative humidity has reached 100%, adiabatic cooling applies to the expanding air and associated temperature drop. Moisture deposits may form on final filters.

FILTER SEGMENTS – AF, FF, RF AND HF

Mechanical Air Filters

Mechanical air filters remove dust by capturing it on the filter medium, the filter element. A mechanical air filter is any type of dry media filter. All of the throwaway air filters used in HVAC systems and Air Handlers are mechanical air filters. Any man made or natural fiber filter is a mechanical air filter. This includes HEPA air filters as well.

Comparing Various Air Filters To MERV Ratings

Dry-media filters exhibit an increase in efficiency as they collect dirt and dust. A dry media filter is at the lowest efficiency rating when it is 'clean'. The increase in efficiency corresponds to a decrease in open area as the media collects fibers and particles. In dust critical environments the user typically can't wait for the increased efficiency. As a result of this type issue, ASHRAE 52.2 defined the minimum efficiency reporting value (MERV) to describe filter performance.

The MERV is based on the worst case performance of a filter through all six stages of dust loading and all particles 0.3-10 microns. Because the rating represents the worst-case performance, end users can use it to assure performance in applications where a maximum particle count must be maintained over the filter's entire life.

ASHRAE 52.1 arrestance and dust-spot tests used either weights or times to generate a ratio, or efficiency. This efficiency was an easy way to describe a filter's performance. Thus, a 50 percent filter would stop a nominal 50 percent of the particles in the air stream as averaged over the test period. Unfortunately, this average over time told a user nothing about performance for a specific particle size at a specific stage in a filter's life.

ASHRAE Standard 52.2 rates filter arrestance differently. Standard 52.2 testing protocol includes the reliable and consistent testing of filter performance on particles of nominal 0.3-10 microns in diameter. This testing provides an accurate and clear description of arrestance at each stage, rather than the average produced by Standard 52.1.

ASHRAE 52.2 Particle Size Ranges

Range	Size (in microns)	Group
1	0.30 to 0.40	E1
2	0.40 to 0.55	E1
3	0.55 to 0.70	E1
4	0.70 to 1.00	E1
5	1.00 to 1.30	E2
6	1.30 to 1.60	E2
7	1.60 to 2.20	E2
8	2.20 to 3.00	E2
9	3.00 to 4.00	E3
10	4.00 to 5.50	E3
11	5.50 to 7.00	E3
12	7.00 to 10.00	E3

The efficiency of the filter is measured on 12 particle size ranges. The twelve size ranges are then placed in three larger groups (E1, E2, E3) and the percentages in each group are averaged

MERV Value	Group 1 Av. Eff.% 0.3 to 1	Group 2 Av. Eff.% 1 to 3	Group 3 Av. Eff.% 3 to 10
1	n/a	n/a	E3<20
2	n/a	n/a	E3<20
3	n/a	n/a	E3<20
4	n/a	n/a	E3<20
5	n/a	n/a	20<35
6	n/a	n/a	35<50
7	n/a	n/a	50<70
8	n/a	n/a	70
9	n/a	E2<50	85
10	n/a	50<65	85
11	n/a	65<80	85
12	n/a	80	90
13	E1<75	90	90
14	75<85	90	90
15	85<95	90	90
16	95	95	95

The average is called the Particle Size Efficiency which is used to determine the Minimum Efficiency Reporting Value (MERV).

MERV Analysis

The required MERV rating for filters will follow directly from the maximum allowable particle concentrations in the three bands of 0.3-1.0 microns, 1.0-3.0 microns and 3.0-10.0 microns.

1. A rating of MERV 10 corresponds to 50-65 percent efficiency for particles 1-3 microns and above 85 percent efficiency for particles 3-10 microns.
2. A rating of MERV 13 corresponds to less than 75 percent arrestance efficiency for particles 0.3-1 microns, above 90 percent efficiency for particles 1-3 microns, and above 90 percent efficiency for particles 3-10 microns.
3. A rating of MERV 15 corresponds to 85-95 percent arrestance efficiency for particles 0.3-1.0 microns, above 90 percent efficiency for particles 1-3 microns, and above 90 percent efficiency for particles 3-10 microns.
4. Ratings of MERV 16 to MERV 20 correspond to HEPA and ULPA filters.

Note: The entire list of MERV ratings based on particle arrestance efficiency is found in Table 12-1 of Standard 52-2.

As an example, if you are concerned with pulling out a high percentage of molds, mold varies in size from about 4 microns to 40 microns.

- The greatest numbers of mold spores are less than 10 microns in diameter.
- The chart indicates a MERV 8 filter will pull out at least an average of 70% of the particles down to 3 microns.
- Pleated filters are available in a MERV 11. The MERV 11 would give you an average of at least 85% mold removal.

The following comparisons are not meant to be definitive:

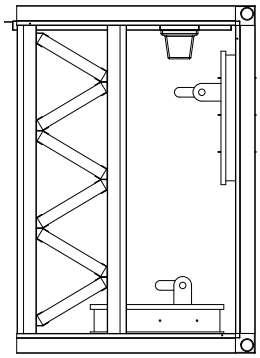
MERV Rating	Particle Size	Applications	Filter Type
1-4	>10 um	Residential Light Commercial Equipment Fiberglass Poly Panel	Permanent Metal Foam
5-8	3 to 10 um	Commercial Industrial Better Res. Paint Booth	Pleated Filters
9-12	1 to 3 um	Res. – Best Commercial Telecommunications Industrial	Best Pleated Rigid Box Rigid cell Bag
13-16	0.3 to 1 um	Smoke Removal General Surgery Hospitals Health Care	Rigid Cell Bags V-Cell Mini-pleat
16-20	0.3 um		HEPA / ULPA

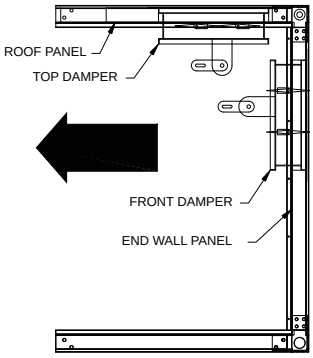
MIXING SEGMENTS & ECONOMIZERS – MB, FM, EE, EF, FD, IP, VE AND VF

Mixing Box/Mixing Segment (MB/FM)

Solution has designed a mixing box (MB) which combines fresh air and re-circulated air by means of interconnected dampers.

Solution's space saving combination filter mixing segment (FM) offers an angle filter as an integral part of the mixing segment to economically provide filtering and mixing capability.





Notes & Options

- The MB/FM Segment typically must be the first segment in direction of airflow.
- Access doors are optional.
- Auxiliary drain pans optional except when bottom opening is selected
- Combination filter mixing segment (FM) provides a full-height access door for filter service.
- Variable size openings and dampers are optional.
- Safety grate option for bottom openings

Hood application – only the following outdoor segments are available

- Mixing box (MB or FM) Economizer (EE or EF) outside air (OA) inlet openings.

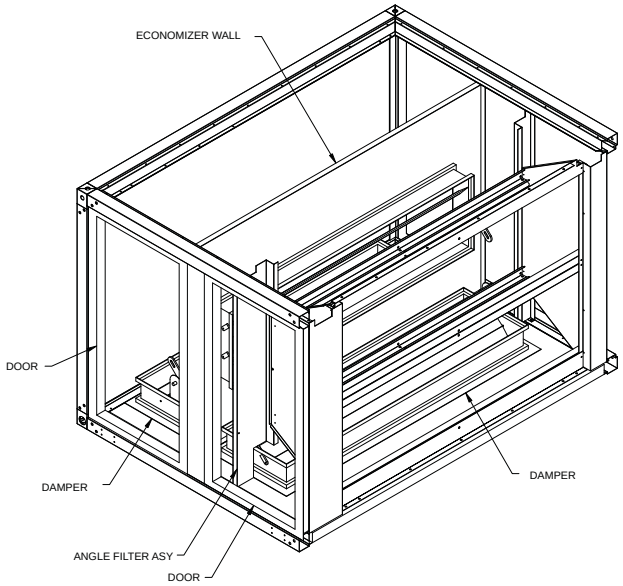
Hood Options

- Bird screen is standard with all hoods
- Moisture eliminator is available as an option

Note: When the moisture eliminator option is selected the moisture eliminator acts as the bird screen. A separate bird screen will not be required.

Economizer

Solution offers numerous economizer configurations for various ventilation applications. The economizer is designed with factory packaged controls in-mind. Correctly set-up economizers will constantly track building pressurization as well as both indoor and outdoor air temperatures using transducers, mixed air sensors and enthalpy control that monitors air temperature and humidity.



Notes & Options

- The EE or EF segment may be first in the air-stream or may be used in conjunction with other segments in an economizer application.

Hood application – only the following outdoor segments are available with hoods

- Fan Exhaust (FE) discharge openings
- Economizer (EE or EF) exhaust air (EA) discharge openings

Hood Options

- Bird screen is standard with all hoods
- Moisture eliminator is available as an option

Note: When the moisture eliminator option is selected the moisture eliminator acts as the bird screen. A separate bird screen will not be required.

Vertical Economizer

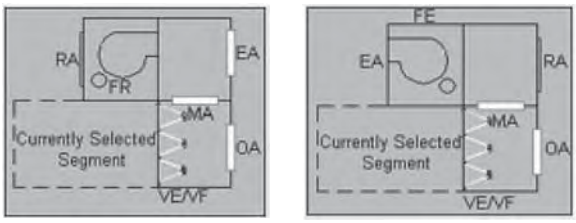
Solution offers a Vertical Economizer arrangement which consists of tiered segments; top and bottom. Both top and bottom segments are designed to be of minimum length required. The VE arrangement is designed to be first in the air-stream unless it is immediately preceded by XA, FR (DWDI), FR (SWSI), FE (DWDI), FE (SWSI).

The VE segment must be configured in a top tier arrangement per the following rules:

1. Only one VE per unit
2. Must be tiered over the MB or FM segment
3. MB or FM segment must have a top damper

General Considerations:

1. VE segment shall be available for all Solution unit sizes provided engineering rules for stacking allow the top section of VE segment to be tiered.
2. VE segment shall be designed for the configurations described in the sketches below.



3. Both top and bottom sections of the VE segment shall be designed to be of minimum length required. The design shall allow the two sections of VE segment to be of different lengths.
4. Sound data shall be provided for all configurations of VE segment.
5. Controls shall be available on VE segment for both top and bottom sections.
6. Filter option shall be available in the bottom section of the VE segment similar to FM segment.
7. Doors are available as an option for indoor units and are required for outdoor units.

Notes & Options

- VE segment will have the same construction materials as the MB or FM segment.
- No optional auxiliary drain pain.
- Optional Access Doors & View-ports.
- Auxiliary drain pans optional except when bottom opening is selected
- Variable size openings and dampers are optional.
- Safety grate option for bottom openings

MIXING BOX OPTIMIZATION CHART

This Mixing Box Optimization chart provides techniques and suggestions to meet the desired needs for your specific mixing box design process. It is a decision-making process in which the effectiveness of a mixing box must be considered. Ideally, mixing boxes should provide adequate mixing.

Mixing Box Assessment	Mixing Effectiveness	Advantages	Disadvantages
Standard Mixing Box with/without Angle Filter	**GOOD APPLICATION** Most effective 1. In constant volume system • Parallel blade control damper • Blade orientation and rotation promotes mixing	• Lowest first cost • Space saving	• Risk of low mixing effectiveness • with filter • with VAV • Risk of nuisance low limit tripping • Risk of stratification
Standard Mixing Box *without filters* and *Sequenced Controlled Dampers ***(sequence listed below)***	**BETTER APPLICATION** Most effective 1 In VAV system 2. With Min Max damper 3. With opposed blade control damper * Sequenced damper control is most suitable for low air flow – low velocity applications	• Lower first cost • Mixes outside and return air more proportionately • Improves system performance at low flow rates • Sequence will add stability to the control loop	• Risk of nuisance low limit tripping • Risk of possible stratification
Standard Mixing Box *without filters* and Static Air Mixer (blender)	**BEST APPLICATION** Most effective 1. Outside air designs at freezing and sub-freezing temperatures 2.Constant or VAV systems *Sequenced opposed control dampers are recommended for VAV systems	• Greatly improves mixing of sub-freezing air streams • Greatly reduces, if not eliminates, stratification in short distances • Works effectively and consistently	• Higher first cost among damper designs • Increases unit length • Some additional static pressure loss

*Suggested sequence of operation as follows:

1) Start the fan with the return air damper fully open and the outdoor air damper fully closed.
   a) An independent signal shall be sent to the Outdoor air damper
      i) Minimum open position
   b) An independent signal shall be sent to the Return air damper
      i) Full open position
2) The outdoor air damper shall modulate further open to admit additional outdoor air as required to satisfy the (mixed air), (discharge air) temperature sensor or IAQ requirements.
3) Once the outdoor air damper is fully open, if additional outdoor air is required, the return air damper shall modulate toward its closed position.

MIXING SEGMENTS & ECONOMIZERS – MB, FM, EE, EF, FD, IP, VE AND VF

Typical Economizer Application

ASHRAE Standards Demanding Economizer Considerations:

ASHRAE 90 - The 'standard' details requirements for a high performance & energy-efficient design of buildings (which includes equipment as part of the building system).

What is high performance?

- Lower energy usage
- Lower life cycle cost
- Durable
- Healthy
- Productive

How buildings use energy?

- Different building types use it differently
- Occupancy & equipment schedule
- Internal vs. external load dominated buildings
- Building occupants

ASHRAE 62 - The 'standard' details Indoor Air Quality issues with the purpose to establish acceptable ventilation procedures & standard-of care.

What are ventilation procedures?

- Mechanical ventilation systems shall include controls, manual or automatic, that enable the fan system to operate whenever the spaces served are occupied
- The system shall be designed to maintain the minimum outdoor airflow as required under any load condition

What is a standard-of-care?

- Guidelines to designers addressing contaminant source control, minimum maintenance activity & frequency, filtration and managing relative humidity

Building Pressurization

Building Pressurization – is defined as the relative air pressure in a building, as compared to the exterior or ambient air pressure. A design amount of outside air must be introduced to insure design building ventilation.

This difference in pressure has a large impact on how the building operates and it can have undesirable if not peculiar impacts on building operations. Over-pressurized buildings will have doorways which are transformed into wind tunnels. Under-pressurization will create a building that has become negatively pressurized and infiltration makes indoor climate control difficult.

The difference between the amount of OA and EA must remain constant at all operating conditions to maintain proper building ventilation and pressurization.

Over Pressurization caused by -

- Too much OA
- Not enough EA

Results in -

- Excessive energy consumption
- Perimeter doors opening

Under Pressurization caused by -

- Too little OA
- Too much EA

Results in -

- Ventilation problems with occupants
- Excessive building odors
- Poor temperature control (infiltration)
- Excessive energy costs
- Difficulty in opening doors

Knowing how to correct and avoid pressurization problems can prevent minor, inconvenient and comfort related issues from growing into insurmountable problems and liability issues.

MIXING SEGMENTS & ECONOMIZERS – MB, FM, EE, EF, FD, IP, VE AND VF

Methods of Pressurization Control

Full Return Air Fan Economizer -

Handles pressure losses through

- Return air system
- Exhaust dampers

Supply Fan handles pressure losses through

- Outside air dampers
- Mixed air dampers

Dedicated Exhaust Fan Economizer -

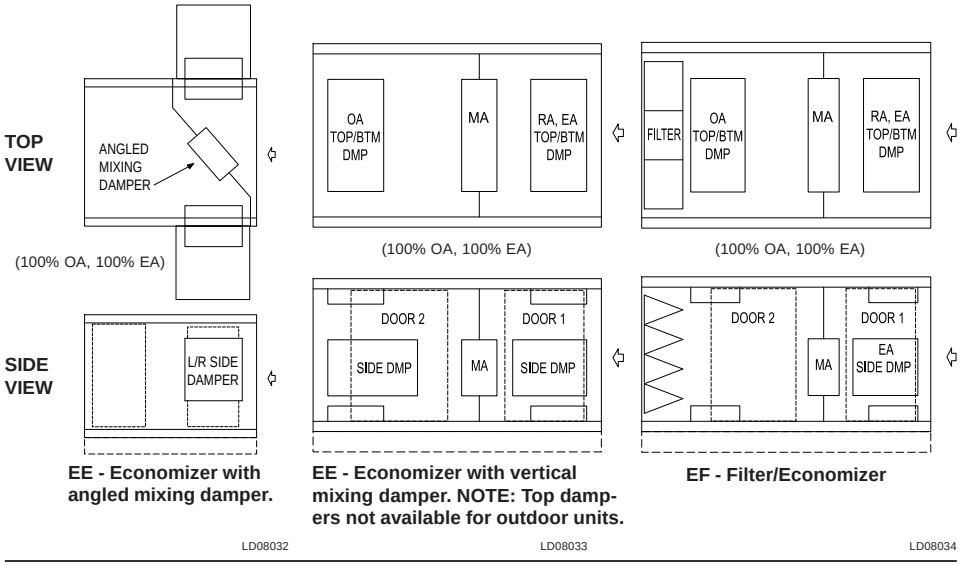
Fan runs only when economizer opens the OA dampers

Handles pressure losses through

- Return air system when in exhaust mode
- Exhaust air path

Building pressurization provides insight in identifying, diagnosing, correcting and most importantly, avoiding some unusual building operational problems.

Economizer Arrangements



EE - Economizer with angled mixing damper.

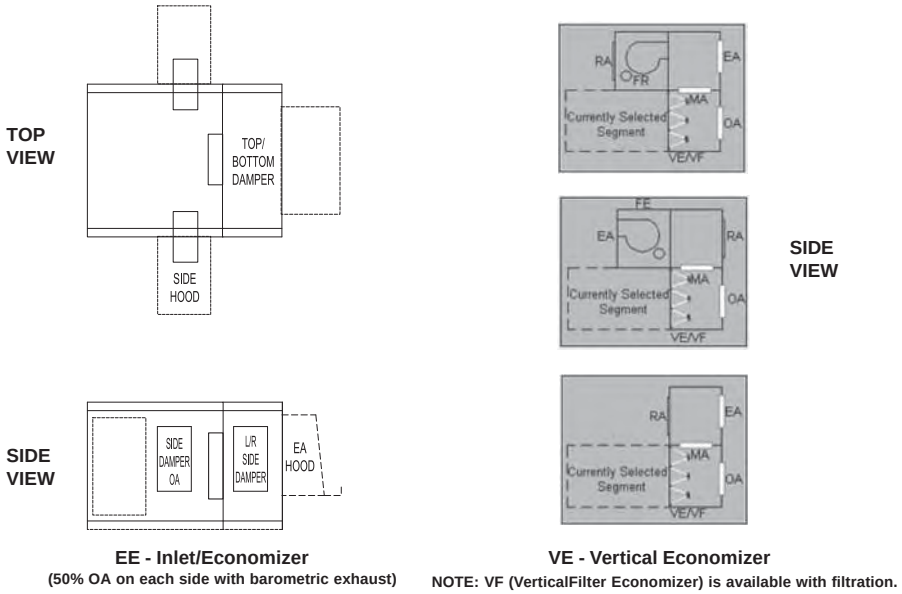
LD08032

EE - Economizer with vertical mixing damper. NOTE: Top dampers not available for outdoor units.

LD08033

EF - Filter/Economizer

LD08034



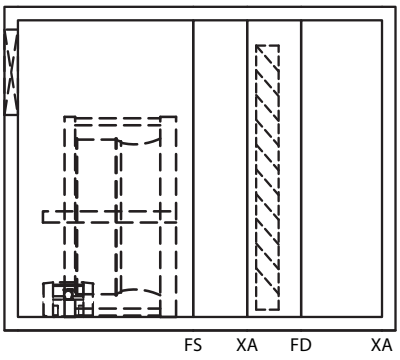
EE - Inlet/Economizer
(50% OA on each side with barometric exhaust)

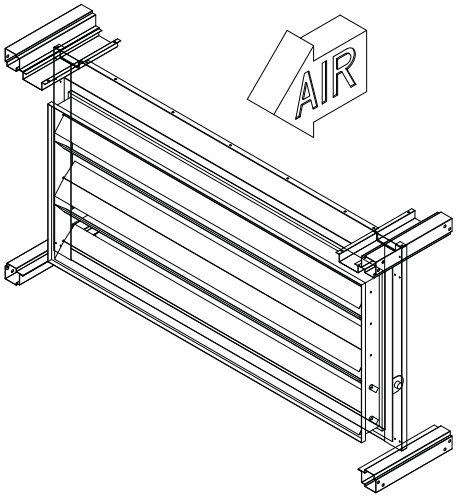
VE - Vertical Economizer
NOTE: VF (VerticalFilter Economizer) is available with filtration.

LD08035

Literature Reference — See Application Guide *'Return & Exhaust Fan Economizers and Building Pressurization'* – Form 100.00-AG3

Face Damper – (FD)





Notes & Options

The FD segment contains a full face damper

- Face dampers are sized to cover whole components downstream within tunnel.

The FD is available for both indoor and outdoor applications.

- The FD can be located first in air stream or last in air stream, only with indoor applications.

Access doors and viewing ports must be located in adjacent segments.

- Access is required immediately upstream of the FD segment to access damper actuator and linkage.

Damper material option:

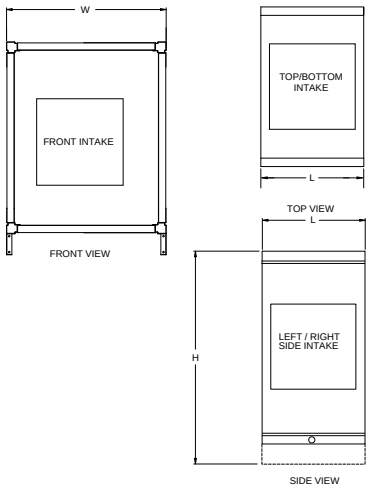
- Galvanized
- Aluminum

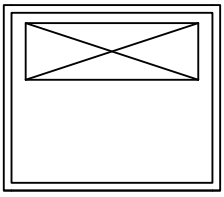
Inlet Plenum – (IP)

The Inlet Plenum is as its name implies; a segment used to provide a proper means of air entry into the air handler.

Openings may be applied to top, bottom, front, left side and right side.

The variable size opening option allows the opening to be properly aligned and sized for airflow convergence and or divergence.





Notes & Options

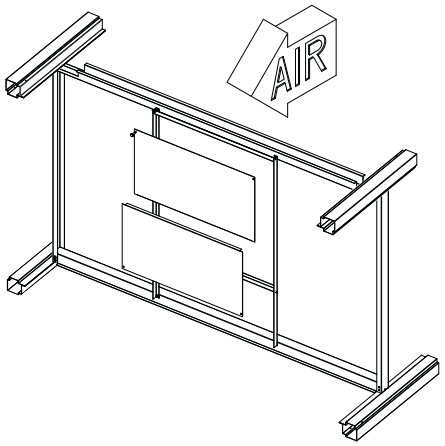
If a plenum fan is used as a return fan and return air is ducted, an IP segment must be provided upstream of the plenum fan.

- Dampers are not available as an option
- Access Door - Optional
- Auxiliary Drain Pans – Optional

ACCESSORY SEGMENTS

Diffuser Segment – (DI)

The diffuser segment is constructed of heavy gauge galvanized steel with a built-in perforated plate, which prevents high velocities through the center of the downstream component. This segment is mainly used for blow-thru type applications immediately after a DWDI fan or locations where even air distribution across the unit cross section is a necessity.



Notes & Options

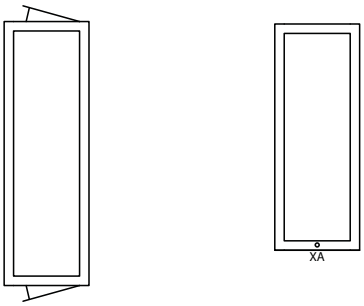
The Diffuser Segment must be placed immediately downstream of a DWDI fan segment when filters, attenuators, humidifiers, electric heater and/or coils immediately follow the fan.

- Auxiliary Drain Pan - Optional
- Access Door – Optional

Access Segment – (XA)

The Access Segment is a functional segment provided to allow access-to or inspection-of any component in adjacent segments. The access segment assists in determining the best segment arrangement for a specific function and or layout.

It is designed for flexibility with full sized access doors and variable segment length.



Notes & Options

Access Segments may be used at any point in the unit configuration; positive pressure (blow thru) or negative pressure (draw thru) configurations.

Access segments may be provided for maintenance, cleaning, service and or spacing for correct air flow requirements.

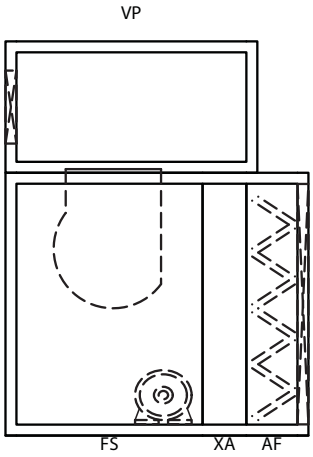
- Auxiliary Drain Pan - Optional (minimum segment length applies)
- Access Door – Optional (both sides of the unit -minimum segment length applies)

Vertical Plenum – (VP)

The Vertical Plenum (VP) is a segment designed for vertical configurations (top tier) with unique discharge arrangements.

Multiple and variable size supply air openings are available through the VP segment.

The VP segment may be applied as an acoustical chamber, with perforated panel option, that dampens low frequency sound. In addition, the air stream expansion reduces turbulence and creates an acoustical end reflection.



Notes & Options

Discharge locations available are top, front, rear, left side and right side.

Discharge opening options are rectangular, round and oval.

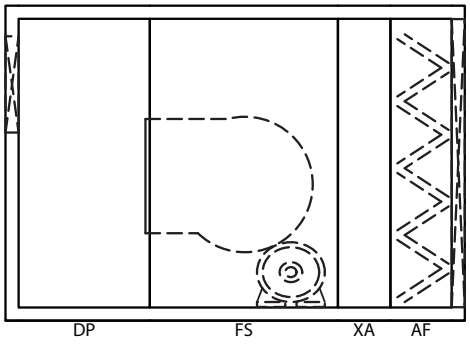
Doors are optional (Inward opening for positive pressure)

Discharge Plenum – (DP)

The Discharge Plenum (DP) is a segment designed for horizontal configurations with unique discharge arrangements.

Multiple and variable size supply air openings are available through the DP segment.

The DP segment may be applied as an acoustical chamber, with perforated panel option, that dampens low frequency sound. In addition, the air stream expansion reduces turbulence and creates an acoustical end reflection.



Notes & Options

Discharge locations available are top, bottom, rear, left side and right side.

Discharge opening options are rectangular, round and oval.

- Auxiliary Drain Pan - Optional
- Access Door – Optional (both sides of the unit - Inward opening for positive pressure)

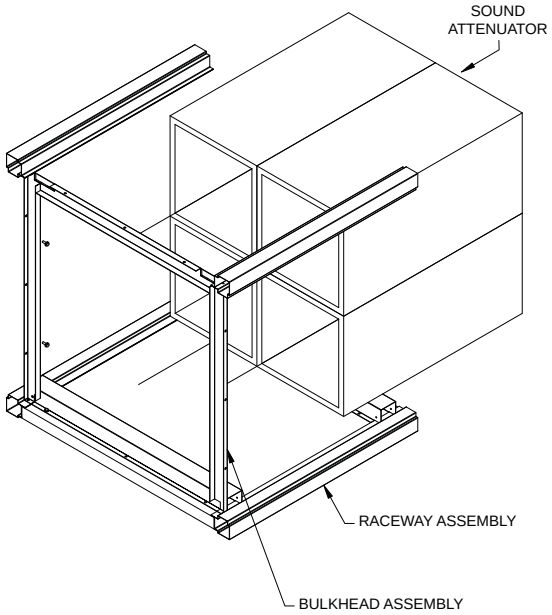
ACCESSORY SEGMENTS

Sound Attenuator – (AT)

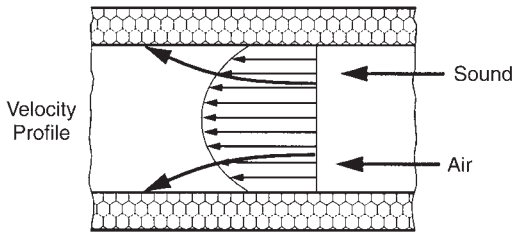
Sound Attenuators are rated for two flow conditions, FORWARD and REVERSE.

- Forward flow occurs when air and sound-waves travel in the same direction, as in a supply air duct or fan discharge.
- Reverse flow occurs when sound-waves and air travel in opposing directions, as in a typical return-air system.

Because attenuation values are generally higher in the first five octave bands in the reverse flow mode, compared to the forward flow mode, more economical silencer selections can often be made on the return-air systems. These phenomena are illustrated below.

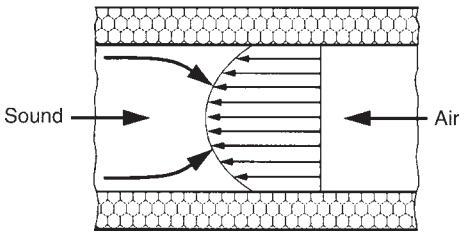


FORWARD FLOW



Under FORWARD FLOW conditions, high-frequency sound is refracted into the duct-silencer walls.

REVERSE FLOW



Under REVERSE FLOW conditions, sound is refracted away from the walls and toward the center of the duct-silencer.

Notes & Options

Silencer Length Options:

- 3ft, 5ft, 7ft

Face Velocity

- Low
- Ultra Low

Media Types:

- Standard
- Film-lined (Hospital media)
- None (No media)

Frequency Range

- Normal
- Low

Casing Materials:

- Galvanized
- Stainless Steel

Access doors and viewing ports must be located in adjacent segments.

When AT segment is located immediate downstream of DWDI fan segment a Diffuser segment is needed to ensure even airflow distribution.

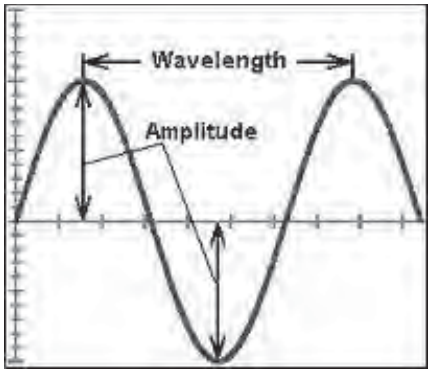
Literature Reference — See Application Guide *'Acoustichecks for Air Handling Projects'* – Form 100.00-AG2 & *'Fundamentals of Acoustics'* – Form 102.20-AG4

Noise & Vibration

Any mechanical device is capable of generating noise and vibration for a variety of reasons. The air handler unit noise emanates simultaneously from three distinct sources: aerodynamic, mechanical, and electrical.

Noise generally applies to any problem in which the ears are the main sensor. Noise is made up of many different sound frequencies at various loudness levels. Noise when compared to vibration is similar in that they both have amplitude and frequency. Usually noise is a much lower amplitude and energy content which is measured in db referenced to Watts. Typically noise has a much wider frequency range and a higher upper limit than vibration (63Hz – 8KHz)

Vibration generally applies to any problem in which the hands or touching are the main sensor. Amplitude is large when there is a problem. It has much greater energy content with a smaller frequency range (3Hz – 500Hz)



Noise Considerations and Characteristics

Mechanical and electrical noise sources usually begin as vibration and are later transferred into airborne noise. To avoid unsatisfactory noise levels, many factors should be considered at the design stage. Noise is generally considered low quality, unwanted sound. Characteristic words such as tone, pitch, steady, unsteady and intermittent help to define whether the source of the noise is aerodynamic, mechanical or electrical.

Aerodynamic	Mechanical	Electrical
Generated noise is caused by turbulence, high velocities, and instabilities due to pulsation and surge. Technically speaking it relates to pressure pulsations and is characterized by a continuous broadband frequency spectrum with an objectionable superimposed pure tone.	Generated noise has a different sound quality and characteristic. It can have a metallic sound caused by metal-to-metal contact or working noise radiating from belts and bearings. This noise may be constant or intermittent.	Generated noise is a function of motors, relays, motor controls, or unbalanced line voltages into the motor

Vibration Considerations and Characteristics

Rotating devices, such as air handling units, all create vibration which can be transmitted to other parts of the structure. The magnitude of this vibration is subject to a number of things, the most significant of which is the amount of unbalance of the rotating components. The frequency at which this occurs is the operating RPM of the components. There are many different sources of vibration. One of the most difficult tasks is the systematic identification of the vibration characteristic; amplitude, frequency, location or direction.

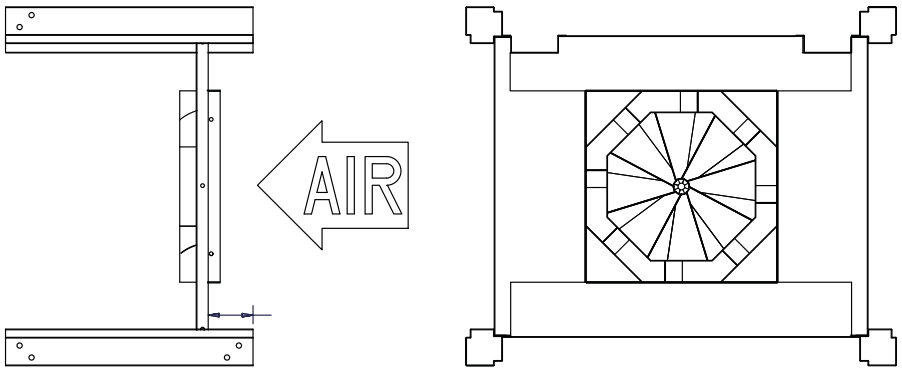
Aerodynamic	Mechanical	Electrical
Vibration is generated when a forced vibration in which the energy and characteristics of the air-stream are large enough to cause turbulence, pulsations or a blade frequency tone. Vibration can also be the result of a resonance (reverberation).	Vibration may occur from unbalance, resonance, looseness and rubbing.	Vibration generated occurs from torsion fluctuations, eddy current induced fields and improper wiring.

ACCESSORY SEGMENTS

Air Blender/Mixers – (AB)

The static mixer provides a high level of mixing in a minimal distance and at a low pressure drop. Mixers placed just after the mixing segment improves mixing outside and return air streams. Mixers work effectively and consistently. There are no moving parts.

Applications (When used):	Features & Benefits:
– Eliminates air stratification – Reduces low limit-stat nuisance trips – Improves accuracy of temperature control systems – Mixes outside ventilation air into supply air stream to satisfy IAQ/IEQ requirements – Allows for greater use of economizer operation – Provides uniform velocity profile for even filter loading and enhanced coil performance	– Provides most mixing in shortest possible distance – Requires negligible energy (typical application is between 0.10 - 0.20” w.g.) – Provides expected mixing for every cabinet size – Provides reliable pressure drop rating which includes the effect of mixer to plenum area ratio.



Notes & Options

AB segment should be applied immediately after the mixing box/economizer segment. AB segment is designed to mix air from openings on any combinations of: top, bottom, end and sides.

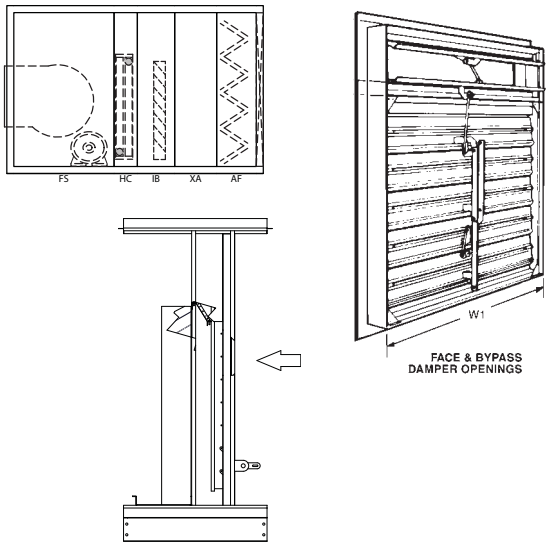
Minimum velocity through a mixer is 400 FPM.

Air mixer arrangements may include one mixer, two horizontal mixers, three horizontal mixers, two vertical mixers or three vertical mixers.

The arrangement depends upon upstream segment configuration.

Door - optional
Drain pan - optional
Mixer material option: Aluminum or Stainless Steel

Face & Bypass Damper Segments – (IB), (EB)



Internal Face & Bypass – (TB)

The IB Segment must be located immediately upstream of a reduced face coil.

- Available for indoor or outdoor applications.
- Designed to divert airflow around a coil.

When a full face coil is required downstream of the reduced face coil, access segment(s) must be included between the coils.

IB segment is used to control

- Humidity
- Low temperature flows across water coils

Notes & Options

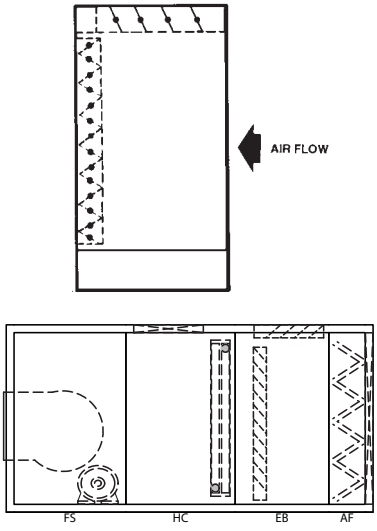
Access doors and viewing ports must be located in adjacent segments.

- An 18” access door is required immediately upstream of the IB segment to access damper actuator and linkage.

Damper material option:

- Galvanized
- Aluminum

External Face & Bypass – (EB)



Each EB segment must be configured with a “bypass air inlet” downstream in the configuration for reintroducing the bypassed air to the unit. The EB segment cannot exist without such a “bypass air inlet” partner.

- The EB segment is available for indoor application only

The external face and bypass damper is located upstream of a full-face coil. External Bypass damper is a balanced opposed blade face damper with interconnecting linkage.

- Bypass duct is to be field supplied

Notes & Options

Damper material option:

- Galvanized
- Aluminum

Drain pan is optional

Door is optional

- It is designed to divert airflow through an external bypass duct.
- External Bypass segment assumes ‘top’ outlet.

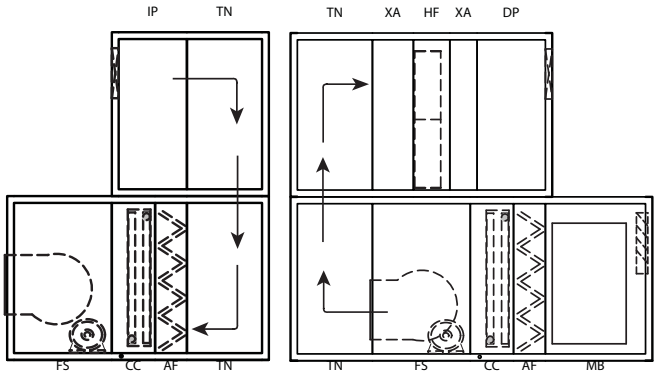
ACCESSORY SEGMENTS

Turning Segments – (TN)

The purpose of the Turning Segment is to assist air turning in a vertical direction.

A Turning Segment (TN) can only be located at the end of a unit configuration.

Segment lengths are engineered for a variety of tiered space saving configurations.



Notes & Options

TN segments are available for configuring in both top and bottom tiers.

Drain pan is optional for bottom tier segments.

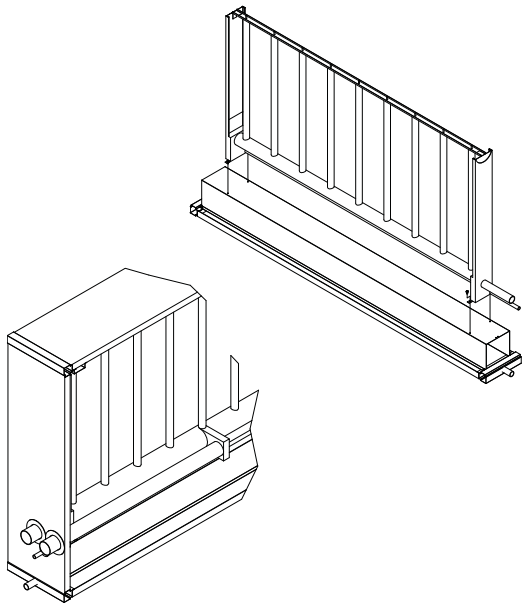
Access Door – Optional (both sides of the unit - Inward opening for positive pressure)

Humidifier Segment – (HM)

Adding humidification for full winter comfort and productivity is just as important as air conditioning in the summer months. Temperature control must be combined with humidity control to maintain proper comfort parameters. ASHRAE 62 indicates that relative humidity is part of acceptable ventilation procedures & standard-of care

Solution provides a standard steam injection distribution type humidifier with a short absorption manifold for use where short steam absorption distances are critical.

- Steam is distributed evenly through the full length of the manifold.
- The header size, number and spacing of distribution tubes shall be determined so that all steam is absorbed by the air before reaching the next component in the air stream depth.



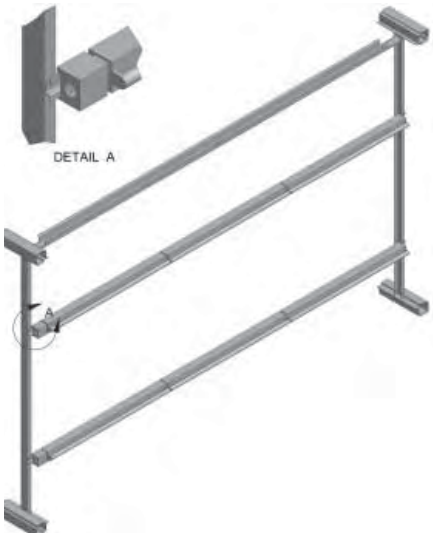
Notes & Options

- Electric, gas and steam-to-steam generator types
- Optional auxiliary drain pan
- Optional access doors
- Optional controls
- The recommended location of the HM segment is downstream of the HC segment but upstream of the CC segment.
- The humidifier segment can not be configured upstream of a HEPA filter segment.
- The humidifier segment may be configured upstream of RF, FF, and AF filter segments.
- Valve package shall be supplied and shipped loose. Field Installation and wiring is required.
- The Humidifier Vendor humidifier selection software shall size the valve package.
- Valves cannot be selected as an off-the-shelf item; each valve has a specific plate/orifice specifically cut per order specifications.
- Control valve actuation shall be electronic and shall be compatible with either a 0-10V DC signal or a 4-20 mA control signal.
- Factory mounted controls are not available in the Humidifier segment. Any FMED device in a downstream segment should be located at least the absorption distance away from the humidifier manifold.
- Usual humidifier headers are located the same side as coil headers.
- Optional stainless steel supports and liner

UV Segment – (UV)

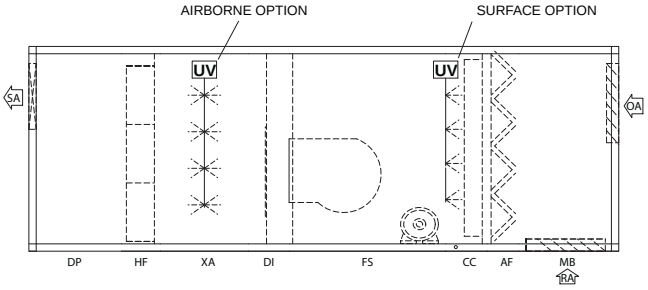
Johnson Controls has developed UV-C lighting options that control the growth and transfer of surface and airborne microbial agents. By incorporating UV light options into your air handling unit it is now possible to control micro-biological infestations, using ultraviolet light technology to disinfect the unit, thereby maintaining the cleanliness of the unit and the re-circulated air of the space being conditioned. By eliminating a multitude of micro-organisms, IAQ is improved and occupants are healthier.

Surface Decontamination Option – is done by incorporating UV-C lights in the coil segment downstream of all cooling coils and above all drain pans. In this application reflectivity of the UV light is of dominant importance. Exposure time is unlimited. Any increase in reflectivity enhances the UV effectiveness and efficiency. The kill rate increases dramatically with this application method.



Airborne Inactivation Option – is accomplished by installing the stand-alone "Airborne Inactivation" segment upstream and/or downstream of all cooling coil segments to control airborne microbial agents. UV-C lights for this type of application are of higher intensity and are designed for "On-the-fly" kill of airborne contaminates. Lamps are configured for 360° UV irradiance for maximum air-stream cleansing.

Combining Both Options – If both Surface Decontamination and Airborne Inactivation options are used together, they can virtually clean your unit and the air you breathe. Working together with various filtration systems and complying with the requirements of ASHRAE Standard 62.1 will assure the best possible IAQ when a designer combines all of these technologies.



Notes & Options

Optional Radiometer

- Radiometer detects and measures intensity of radiant thermal energy

Optional Access Door

- Access is optional for servicing the UV lights.
- Mechanical interlock switch to assure that the UVC assembly will be de-energized when accessed.
- Optional View-port

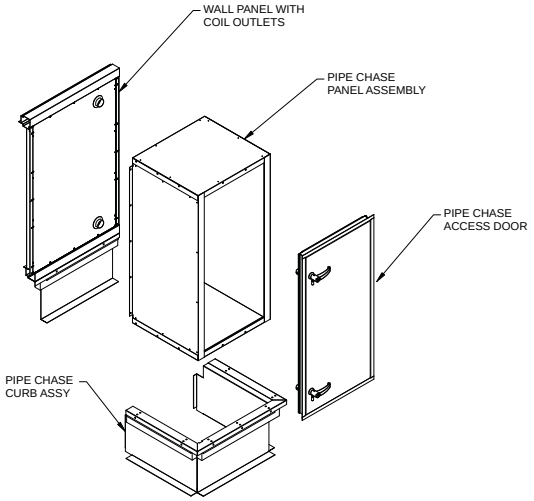
Optional stainless steel supports and rails

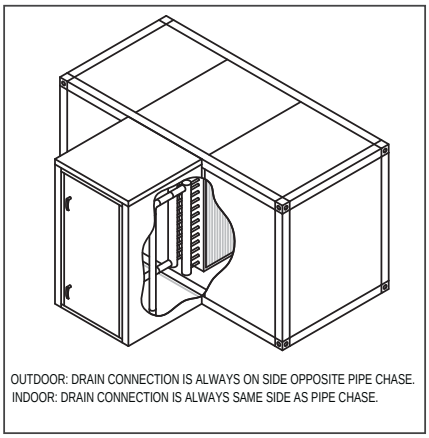
Literature Reference — See Application Guide — *'Solution® Air-Handling Units UV-C Light Options'* – Form: 102.20-AG16 & *Specification Sheet* – Form: 102.20-S16

ACCESSORY SEGMENTS

Pipe Chase Enclosure

1. The Pipe Chase may be selected in various depths.
2. The Pipe Chase may be applied to XA, HC, CC, VC, IC or IG segment.
   a. These segments must be on the bottom tier of an indoor or outdoor unit.
3. Roof, floor, side and end panels will be double wall construction.
4. Pipe chase doors
   - All pipe chases must have at least one door.
5. Pipe chase curb
   - The pipe curb under a pipe chase will be level with the curb under the unit.

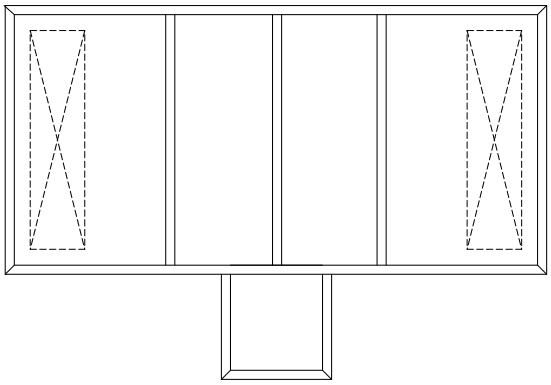



OUTDOOR: DRAIN CONNECTION IS ALWAYS ON SIDE OPPOSITE PIPE CHASE.
INDOOR: DRAIN CONNECTION IS ALWAYS SAME SIDE AS PIPE CHASE.

Roof Curb

Johnson Controls recommends that an HVAC factory curb always be provided. Solution curbs are built to fit the unique footprint of each air handler. Solution also provides specific drawing and specification data for each unit and curb. These documents provide vital data such as unit dimensions, weight, component details, cross braces, supply & return opening layout dimensions, and notes which are unique to each unit.

Although insulated curbs are specified in many cases, the contractor responsible for the roof typically supplies the insulation function.

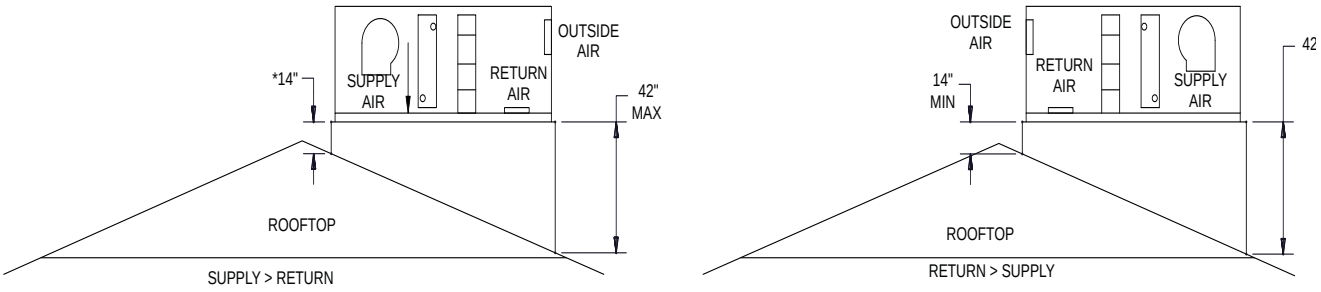


Notes & Options

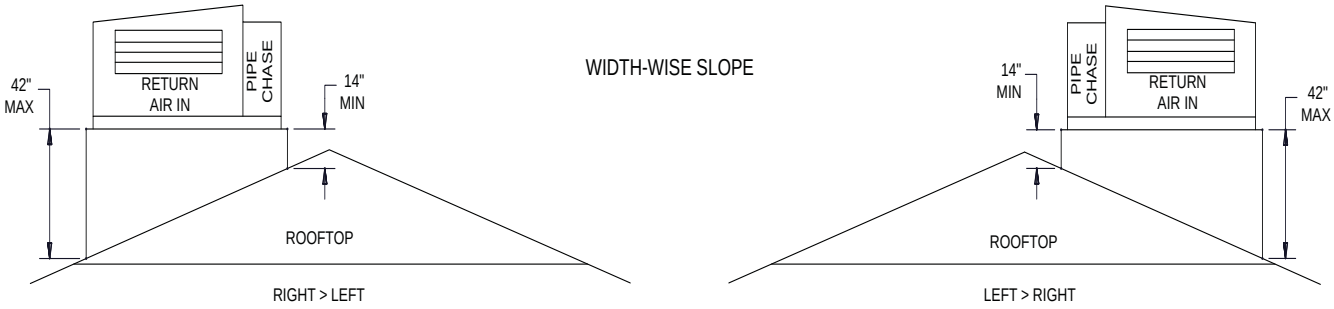
1. Johnson Controls does not recommend vibration isolation be provided on both the fan skid, inside the unit, and the curb, outside the unit, without credible testing results.
2. Using improperly designed internal and external isolation springs can increase vibration.
3. Dual vibration isolation applications must be designed by a licensed Professional Engineer specializing in vibration isolation design.
4. Units with a baserail and a bottom opening: duct connection is flush with the bottom of the unit, not flush with the baserail.

SLOPED CURB

LENGTH-WISE SLOPE



WIDTH-WISE SLOPE



Special Curb Requests

Spring isolation curbs

Roof curbs that incorporate adjustable spring isolators into the curb as a single component. Most isolation curbs are designed for 1" static deflection springs. The springs are mechanically fastened and sized within the frame to ensure uniform deflection for the entire system. The vibration eleimination portion of the curb is constructed of structural steel and should be designed to match the bottom of the rooftop unit. Usual operating height is 21" with options for different heights.

Seimic isolation curbs

Roof Curbs that incorporate seismic isolation as a fully adjustable support system specifically designed for unit vibration and seismic/wind restraint. Seismic isolation curbs are designed to meet superimposed live and dead loads, including equipment and other construction loads to be supported by the curb. The curb contains mountings designed and rated to resist seismic forces in all directions.

Literature Reference — See Application Guide **—** *'Roof Curb & Unit Application'* – Form 100.00-AG11

CONTROLS

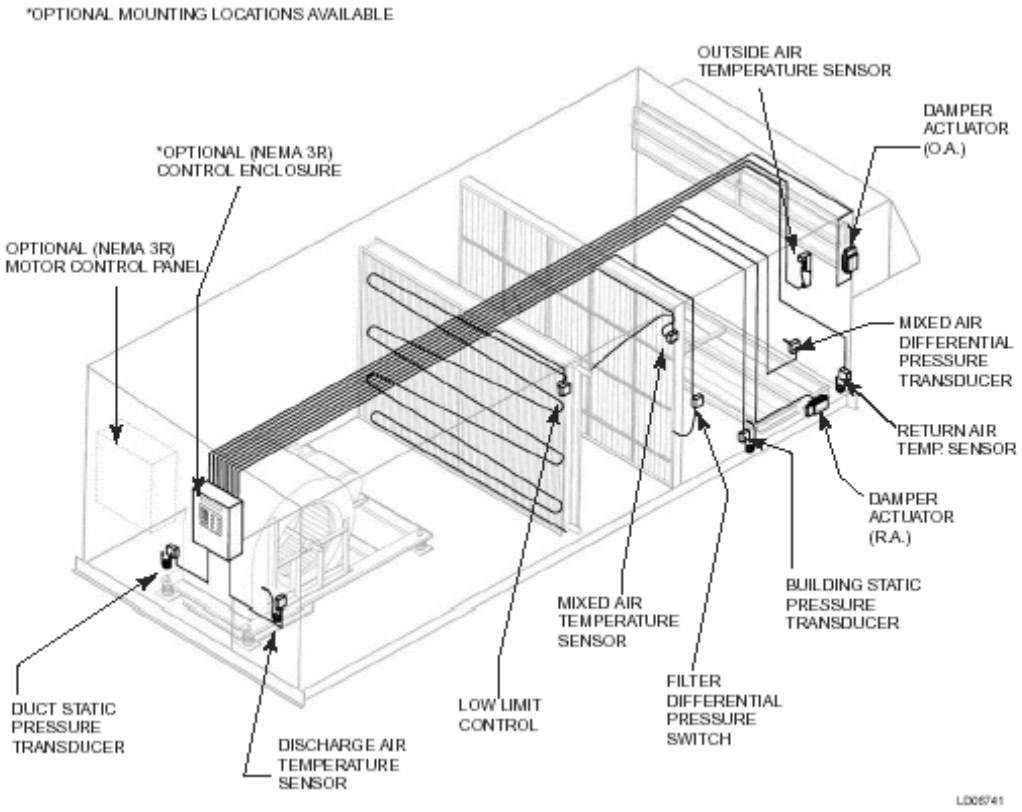
Factory-Packaged Controls – (FPC)

YORK Factory-Packaged Controls assure you of getting:

- A complete factory-engineered system
- Reduce costs by taking the guesswork out of control installation
- A higher quality control system direct from the factory
- Full service support

Typical FPC Wiring

Location of wiring harnesses are typically opposite the high voltage. See “Power-Wiring Options diagram on page 62.



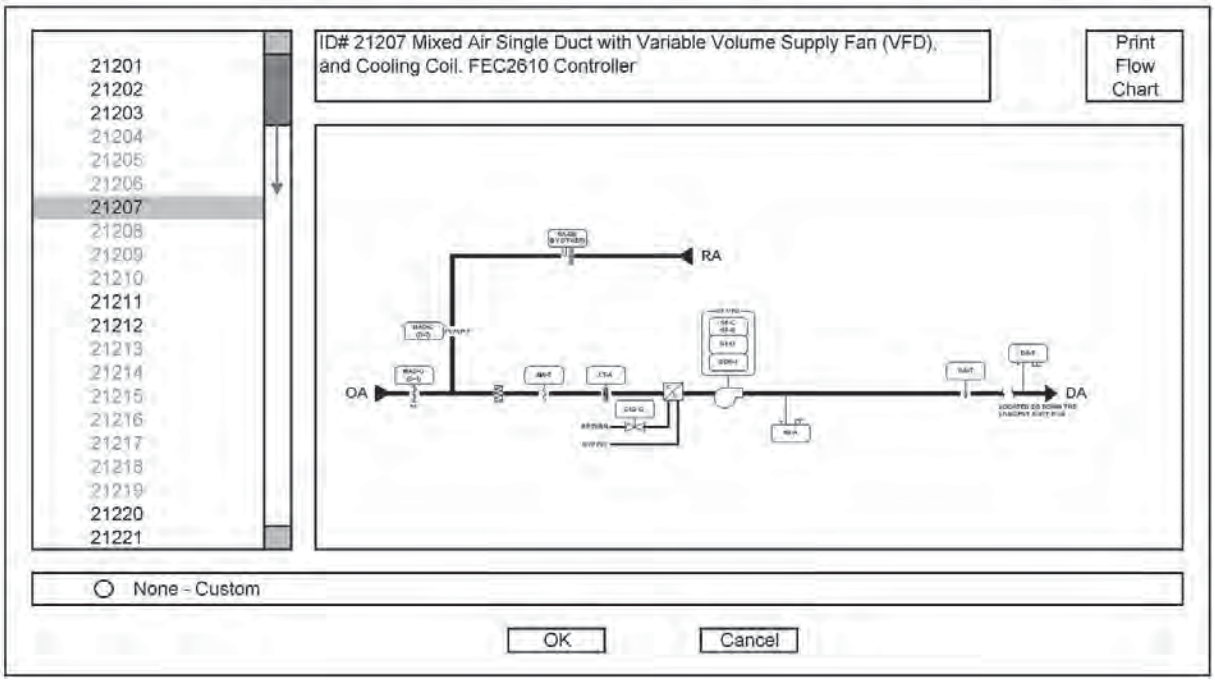
Notes & Options

Factory mounted devices are available as packaged ‘Standards’ kits, which are defined as pre-engineered system applications. Most likely several ‘Standards’ will “fit” a given AHU configuration.

Devices are available in a variety of options from mount-only with no control panel to a complete mounted, wired and factory-tested with the Johnson Controls Metasys FEC series controller.

Software Process

The software process will automatically apply the devices to the functional segments required for the control method.



Field Equipment Controller (FEC)

Our open design FEC conrollers use the industry standard BACnet MS/TP open communication protocol – customers can use devices from other vendors on the network, don't have to stay with one vendor which provides wider options to the customer and consulting engineer

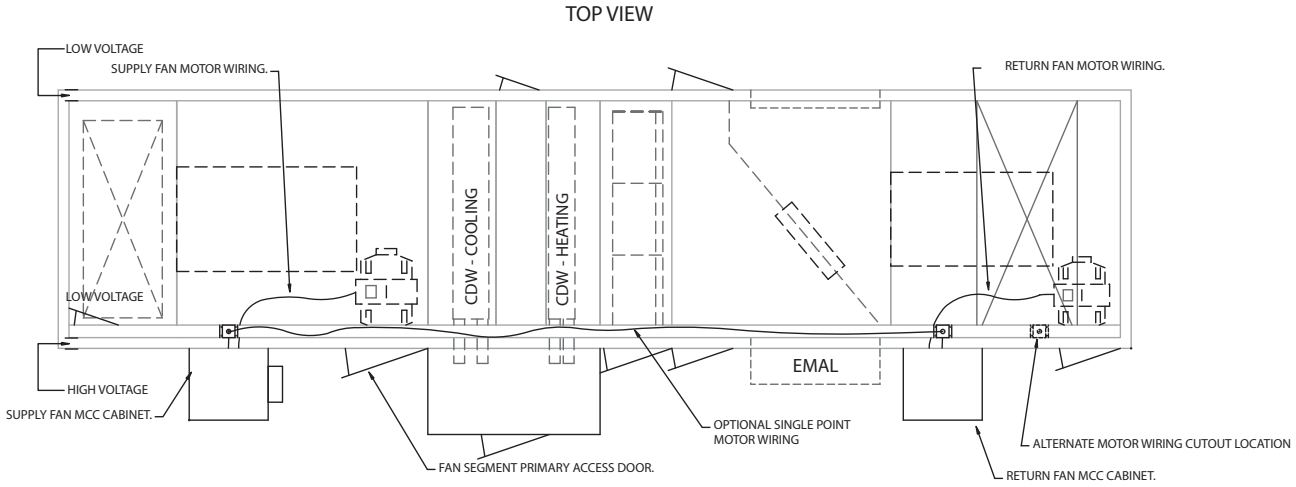
On time, on budget – Standards reduce engineering and installation time and result in the lowest possible installed cost. New tools like CCT reduce configuration and commissioning time.

Minimize issues – Johnson Controls builds reliability into each device. Our documentation and training are excellent so the devices are installed correctly the first time.

Reduce operating costs – With adaptive tuning, the system uses process condition information it acquires and adapts for improved control without manual intervention. State-based control reduces wear and tear on actuators and other components by allowing the system to be in only one mode at a time. For example, only heating or only cooling.

CONTROLS

Power Wiring Options



Notes & Options

All motor wiring will be sized and installed based upon National Electrical Code requirements. The wire-ways will be categorized as follows:

- High Voltage – (120V and higher) is usually on drive side of the product
- Low Voltage – (24V) is usually on opposite drive side.
- All motor wiring will be installed neatly in perpendicular and/or parallel planes with the unit walls and floors.

Single Point Power (SPP) is defined as:

1. ALL electrical loads in a specific unit configuration wired to a common point of connection through the proper motor control protection devices. This requires the customer to bring only one source of power to the unit.
2. Where motor controls (VFD, starter or wired disconnect) are NOT selected, no motor wiring shall be provided. Should 120V or 24V elements be selected where motor controls are not included, they shall require field wiring.
3. Where multiple motor control devices are selected, optionally, single point power connections shall be provided. The field power supply point shall be the supply fan segment.
4. Where an external wired disconnect option is selected for either supply or return/exhaust fans (or both), single point wiring shall NOT be available.

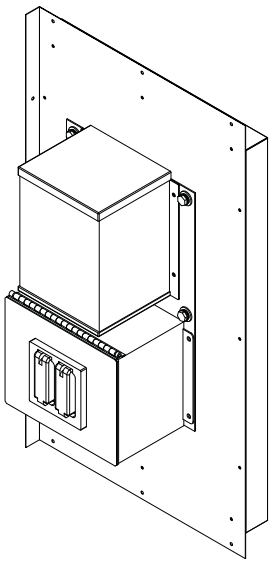
There are three different sizes of transformers available; 150VA, 500VA, and 2000VA.

- The transformer being the device, used to transform power from a primary voltage of 460 volts, 230 volts, or 575 volts, to a secondary voltage level. An example of a secondary voltage would be 120 volts.

A disconnect panel will be required anytime there are (2) or (3) 3-phase loads that require a common factory terminated wiring connection. A maximum of (3) 3-phase loads are allowed for single point power option.

3-phase loads are as follows:

i. Supply Fan Motor Controller
ii. Return / Exhaust Fan Motor Controller.
iii. Gas Heater.
iv. Electric Heater.
v. Energy Wheel Motor Controller.



INDUSTRY FORMULAS

Electrical

Watts ÷ Amps = Volts

Volts x Amps = Watts

Watts ÷ Volt = Amps

Volt (V) = a measure of electrical potential

Watt (W) = a measure of power an electrical device consumes

Amp (A) = a measurement of rate of flow of electrons along a wire

Kilowatt (kw) = a thousand watts

BTU = KW x 3415

1KW = 1.34 HP

1 HP = 2545 BTUH

$$\text{PUMP KW} = \frac{\text{FLOW (gpm) x PD (ft)}}{\text{5311 x E pump x E motor}}$$

$$\text{PUMP HP} = \frac{\text{FLOW (gpm) x HEAD (ft}}{\text{5311 x E pump x E motor}}$$

$$\text{FAN KW} = \frac{\text{.7457 x BHP}}{\text{E motor}}$$

$$\text{FAN HP} = \frac{\text{CFM x SP}}{\text{6350 x E fan}}$$

1.73 = √3 FOR THREE PHASE SERVICE

$$\text{FAN STATIC EFF} = \frac{\text{CFM x SP}}{\text{6350 x BHP}}$$

$$\text{FAN MECH EFF} = \frac{\text{CFM x TP}}{\text{6350 x BHP}}$$

Basic Fan Laws

CFM varies directly as the RPM

$$\frac{\text{CFM1}}{\text{CFM2}} = \frac{\text{RPM1}}{\text{RPM2}}$$

Static pressure varies as the square of the RPM

$$\frac{\text{SP1}}{\text{SP2}} = \frac{(\text{RPM1})2}{(\text{RPM2})2} = \frac{(\text{CFM1})2}{(\text{CFM2})2}$$

HP varies as the cube of the RPM

$$\frac{\text{BHP1}}{\text{BHP2}} = \frac{(\text{RPM1})3}{(\text{RPM2})3} = \frac{(\text{CFM1})3}{(\text{CFM2})3}$$

Drive Calculations

Motor RPM x Motor Pulley PD = Blower RPM x Blower Pulley PD

Example:

$$\frac{1{,}750 \times 7.2}{10.6} = 1{,}190 \text{ Blower RPM}$$

10% too much CFM:

$$\frac{1{,}750 \times 7.2}{1{,}190 \times (0.90)} = 11.8 \text{ “ PD Blower Pulley}$$

Air

TOTAL COOLING LOAD (MBH) = 4.5 x CFM STANDARD AIR x (ENTHALPY ENT. AIR - ENTHALPY LVG. AIR) / 1000

4.5 = 0.075 (WT. OF STD. AIR, # / FT3) x 60 (MIN./HR.)

$$\text{SENSIBLE COOLING LOAD (MBH)} = \text{CFM x 1.08 x } \frac{\text{(EDB-LDB)}}{1000}$$

1.08 = 0.075 (WT. OF STD. AIR, # / FT3) x 60 (MIN./HR.) x .24 (Specific Heat of dry air)

$$\text{SENSIBLE HEAT RATIO} = \frac{\text{SH}}{\text{MBH/Sq. Ft. x FA x 1000}}$$

TOTAL COOLING LOAD (BTW/HR) = GPM x 500 x (EWT-LWT)

500 = 8.33 (WT. OF H20 @ 60 deg F, # / GAL) x 60 (MIN./HR.) x 1.0 (Specific heat of water)

Metric Conversions

CFM x 1.6992 = m3/hr

CFM x 0.4719 = L/s

HP x 0.7457 = kW

Ft/min x 0.00508 = m/s

Inch x 25.4 = mm

Lb x 0.4535 = kg

BTU x 0.00029 = kWh

Gpm x 0.063 = L/s

GUIDE SPECIFICATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Indoor and outdoor air handling units and components as scheduled and shown on drawings.

B. Motor disconnects, motor starters, and variable frequency drives.

1.02 RELATED SECTIONS

A. The requirements of the General Conditions, Supplementary Conditions, Division 1, equipment schedules, and drawings apply.

1.03 REFERENCES

A. AMCA 99 – Standard Handbook

B. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes

C. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters

D. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating

E. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings

F. ANSI/UL 900 – Test Performance of Air Filter Units

G. ARI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment

H. ARI 410 – Forced-Circulation Air Cooling and Air Heating Coils

I. ARI 430 – Testing and Rating of Central-Station Air Handling Units

J. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size

K. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality

L. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings

M. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.

N. NFPA 70 – National Electric Code (conductors, equipment and raceways)

O. NFPA 90A – Installation of Air Conditioning and Ventilation Systems

P. SMACNA – HVAC Duct Construction Standards

Q. UL-181 – Mold Growth and Humidity Test

R. UL-1995 – Standard for Safety for Heating and Cooling Equipment

S. ISO/PWD 13261-3 – Sound Power Rating of air-conditioning and air-source heat pump equipment: Part 3, Ducted Equipment.

T. ISO 9614 – Determination of sound power levels of noise sources using sound intensity: Part 1, Measurement at discrete points; Part 2, Measurement by scanning, and Part 3, Precision method for measurement by scanning.

1.04 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.

B. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance requirements and dimensional requirements.

C. If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:

1. Structural supports for units
2. Size and location of concrete bases/housekeeping pads
3. Location of roof curbs, unit supports and roof penetrations
4. Ductwork sizes and connection locations
5. Piping size and connection/header locations
6. Interference with existing or planned ductwork, piping and wiring
7. Electrical power requirements and wire/conduit and over current protection sizes.
8. Trap height requirements

D. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

1.05 RATINGS AND CERTIFICATIONS

A. Air Handling Unit safety: ETL or UL 1995

B. Air Handling Unit energy use: ASHRAE 90.1

C. Fans: AMCA 210

D. Air Coils: ARI 410

E. Air Handling Unit certification program: ARI 430

F. Filter media: ANSI/UL 900 listed Class I or Class II

G. Control wiring: NEC codes & ETL requirements

H. Motors: Federally mandated Energy Policy Act (EPACT).

I. Airflow Monitoring Stations: AMCA 611-95

1.06 SUBMITTAL DOCUMENTATION REQUIRED

A. Furnish fan performance ratings and fan curves with specified operating point clearly plotted.

B. Furnish drawings indicating unit dimensions, required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.

C. Furnish performance report showing fan, motor, coil, and component performance details. Performance report shall detail unit casing performance and include materials, gauges, and finishes.

D. Furnish operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; spare parts lists, and wiring diagrams.

GUIDE SPECIFICATIONS

E. Adjust and report performance ratings for the proper altitude of operation.

F. Report air-handling unit performance ratings in accordance with ARI-430 (static pressure, airflow, fan speed, and fan brake horsepower).

G. Report static pressure profiles by component section.

H. Report coil ratings in accordance with ARI-410 (capacities and pressure drops).

I. Report and rate sound power levels in accordance with ARI-260 (ducted discharge, ducted inlet, free inlet sound).

J. Airflow measuring device performance shall be certified and rated in accordance with AMCA-611. Report data in accordance with AMCA-611. Provide AMCA Certified Rating Seal for Airflow Measurement Performance.

K. Report panel deflection at +/-8" w.g., stated in terms of 'L/X' where 'L' is the casing panel length and 'X' is a constant provided by the AHU manufacturer.

L. Report casing leakage rate at +/-8" w.g., specified in terms of percentage of design airflow.

M. Report weight loads and distributions by component section.

N. Report product data for filter media, filter performance data, filter assembly, and filter frames.

O. Report electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

P. Report motor electrical characteristics.

[Tip 1]: ARI 430 established testing, rating and conformance requirements for AHUs. To claim compliance, manufacturers must periodically submit production AHUs to ARI for testing.

[Tip 2]: ARI 410 established testing, rating and reporting standards for air coils. This includes special attention to heating and cooling capacity as well as air and fluid pressure drops.

[Tip 3]: ARI 260 standardized the measurement and reporting of sound data for AHUs. It does not require manufacturers to adhere to a certification program to claim compliance. It does require an extensive testing program. (Note: AMCA 300 applies to sound for bare fans only)

[Tip 4]: AMCA 611 details the requirements for certifying the performance of airflow measuring stations. It assures buyers that the reported data is accurate and reliable. Testing is performed by AMCA or by an independent AMCA certified facility.

1.07 DELIVERY, STORAGE AND HANDLING

A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).

B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.

C. Follow manufacturer's recommendations for handling, unloading and storage.

D. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

E. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives; and pack with desiccant bags. Replace desiccant bags every 60 days. For equipment stored in an environment with a relative humidity greater than 60%, change bags every 30 days. Do not store equipment in wet or damp areas even when they are sealed and secured.

G. Seal openings to protect against damage during shipping, handling and storage.

[Tip 5]: ASHRAE 62 established minimum standards for designing, building and operating a building to help ensure acceptable indoor air quality.

H. Provide shrink-wrap around unpainted units. The membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless or size or shape. Tarping is not acceptable.

I. Shrink-wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

[Tip 6]: ASHRAE 62 Section 7.1.3 recommends the protection of equipment on site and during transport. Shrink wrap is a cost-effective, high-quality way to comply with this recommendation.

J. Tarp painted units to protect against rain and road debris during shipping.

K. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.08 EXTRA MATERIALS

A. Provide one set of filters for balancing, and one additional set for final turnover to owner.

B. Provide one extra set of belts, in addition to the factory-installed set.

1.09 WARRANTY

A. Provide warranty for 18 months from date of shipment. Warranty shall cover manufacturer defects. Warranty shall include labor for 12 months from date of shipment. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician. Service technician must be based within 50 miles of job site.

[Tip 7]: Specifying an 18 month warranty helps to ensure that the owner will benefit from a full 12 months of warranty. Specifying labor warranty ensures that the manufacturer will stand by their product for quality and performance during that time. Specifying local service support helps ensure quick response when service is desired or needed.

B. Include factory-provided controls in the parts and labor warranties.

C. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

1.10 SYSTEM STARTUP

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. YORK Solution

B. Approved Equal (Prior written approval by engineer of record is required)

2.02 GENERAL DESCRIPTION

A. Air Handling Unit (AHU) consists of a structural base, insulated casing, access doors, fans, motors, motor controls, coils, filters, dampers, controls, components, and accessories; as shown on drawings, schedules, and specifications.

B. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.

C. AHU shall maintain structural integrity when wall panels are removed.

D. Provide internal components and accessories as specified and scheduled. Components and accessories shall be installed by the AHU manufacturer in an ISO-9002 certified facility.

E. Ship units in one piece. Split units only where necessary for shipping and installation.

F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.

G. For AHU segments that must be broken down for rigging and installation: segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.

H. Manufacturer shall perform a field leakage test to confirm 1% leakage per section 2.25.

I. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

2.03 STANDARDS COMPLIANCE

A. Comply with ratings and certifications referenced in this specification.

B. Manufacturers who do not comply with ARI-430 shall factory test EACH unit to verify brake horsepower rating, airflow performance and total static pressure performance. See specification Section 2.23 (VERIFICATION OF PERFORMANCE) for testing requirements.

[Tip 8]: ARI 430 established testing, rating and conformance requirements for AHUs. To claim compliance, manufacturers must periodically submit production AHUs to ARI for testing.

C. Manufacturers who do not conform to requirements of ARI 260 for ducted discharge and return air sound shall submit EACH unit to an independent sound test laboratory for ARI 260 testing. The test laboratory shall conform to ARI 260, Section 4.4, Test Equipment and Facilities.

2.04 BASE RAIL

A. Provide a structural base rail under the full perimeter of the unit, formed from mill galvanized steel.

B. Provide clearance for proper external trapping of drain pans steam condensate.

C. Provide base rail and lifting lug system that does not require additional support for rigging. Include base rail lifting lugs at each side shipping splits and at unit corners.

2.05 CASING

A. Provide double wall AHU casing. Exposed insulation is not acceptable.

B. Panel assembly shall meet UL standard 1995 for fire safety. Panel assembly shall comply with the requirements of NFPA 90A.

C. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

[Tip 9]: This spec item also found in ASHRAE standard 62, section 5.5.1.

D. Encapsulate insulation with sheet metal so that air does not contact insulation. Panels insulated with fiberglass shall be sealed at each corner and around their entire perimeter, to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.

E. Provide casing with minimum thermal resistance (R-value) of 12 hr-ft2-°F/BTU.

F. Roof, wall, floor, and access door panels shall be galvanized or stainless steel.

G. Provide an additional .125" aluminum diamond tread plate floor liner in access areas.

H. Provide perforated liner in the fan section and other sections as shown on the drawings. The perforated panel shall enclose matte-faced fiberglass insulation.

I. Provide a unit frame of galvanized steel that provides the overall structure of the unit and does not rely on the casing panels for structural integrity. Insulate frame in the same manner as panels, roof, and floors.

J. Provide AHU casing that leaks no more than 1% of design airflow at +/-8" w.g.

K. Provide wall panels and access doors that deflect no more than L/240 when subjected to +/- 8" w.g. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

L. Provide floors and roofs that deflects no more than L/240 when subjected to a 300 lb load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.

M. Provide outdoor AHUs with a roof system that deflects no more than L/240 when subjected to a snow load of 30 lb/ft2. 'L' is defined as the panel-span length and 'L/240' is the deflection at the panel midpoint.

N. Provide outdoor AHUs with a roof sloped at a minimum pitch of 1/4" per foot. The roof shall overhang side and end panels by a minimum of 2".

O. Provide an exterior finish on outdoor units that shows a breakdown of less than 1/8" on either side of a scribed line when subjected to ASTM B117 500 hour, 5% salt spray conditions. This is equivalent to an ASTM D1654 rating of '6'.

2.06 PRIMARY DRAIN PANS

A. Provide drain pans that comply with requirements for the AHU casing (Section 2.07).

B. Comply with the stated intent of ASHRAE Standard 62.

C. Provide a drain pan under each cooling coil and humidifier. Drain pans for cooling coils and humidifiers shall meet the requirements of ASHRAE 62.

D. Provide drain connection made of same material as drain pan. Do not use dissimilar metals because of the risk of galvanic corrosion. Weld connection to the drain pan.

E. Drain pan shall be double wall with an R-value of 12 hr-ft2-°F/BTU. The entire area of the drain pan shall have this level of thermal performance.

F. Insulate plumbing associated with drain pan drains and connections.

G. Provide drain pan under the complete width and length of cooling coil and humidifier sections.

H. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.

[Tip 10]: Casing thermal performance has a direct impact on the owner's utility bill. Spec R-12 for the utmost in energy savings. Many manufacturers employ 2" walls with foam insulation to achieve this high thermal performance. With fiberglass insulation, 4" walls may be required to achieve R-12.

[Tip 11]: Some manufacturers do not insulate the frames of their units, leaving the casing vulnerable to sweating and energy loss.

[Tip 12]: Some manufacturer's casings leak 5% or more. Ensure that energy is not wasted by outward leakage and that conditioned air is not contaminated by inward leakage. Leaky units are also prone to sweating at their leak points. 1% leakage at design static pressure is a very common benchmark for leak integrity.

[Tip 13]: When static pressure in a unit changes and panels deflect, leakage occurs. Over time, panels experience metal fatigue, leading to even more leakage. This wastes energy and compromises IAQ. Spec L/240 for the most rigid and leak-free casing. Specifying sheet metal gauges does not guarantee rigid panels. Foam-insulated panels may be required to meet this performance.

[Tip 14]: Floor systems are the most prone to leakage than the other panels of the casing. Every time someone walks on the AHU floor, panels deflect, leading to leakage and sweating. Spec L/240 for the most rigid and leak-free floor. Specifying sheet metal gauges does not guarantee rigid a rigid floor. Foam-insulated panels may be required to meet this performance.

[Tip 15]: On outdoor units, roof panels are more prone to leakage than wall panels due to high thermal stress and snow loads. Ensure that performance is achieved on the roof by specifying L/200 or higher.

[Tip 16]: Poorly designed drain pans are often breeding grounds for mold and poor IAQ. ASHRAE 62-2001, section 5.11.1 states that drain pans "…shall be sloped at least 1/8" per foot from the horizontal toward the drain outlet…whether the fan is in the on or off position." Section 5.11.2 states that "The drain pan outlet shall be located at the lowest point(s) of the pan."

[Tip 17]: Some drain pan designs may call for less insulation at the lowest points of the pan.

[Tip 18]: This plumbing is difficult to access and service. Uninsulated connections may lead to sweating and puddling beneath the unit.

GUIDE SPECIFICATIONS

I. Provide a minimum of 1” clearance between the drain pan and any coil casing, coil support or any other obstruction.

[Tip 19]: YORK recommends this clearance so that the drain pan can be cleaned and inspected without requiring coil removal. ASHRAE 62 recommends annual inspection during the cooling season and cleaning if necessary.

J. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

K. Provide drain pan sloped in at least two planes by at least 1/8” per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.

2.07 ACCESS DOORS

A. Provide access door(s) that meet requirements for the AHU casing.

B. Provide industrial style stainless steel hinges that permit 180 degrees of door swing.

C. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or “paw” latches are not acceptable.

D. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle.

E. Provide access doors with a locking hasp to accommodate a lockout device.

F. Provide double-pane viewing windows as shown on the elevation view drawings. Windows shall be a non-condensing type consisting of an integrated silica desiccant dehumidification layer. Minimum dimension shall be 3” x 8”.

2.08 PIPE CHASE CABINET

A. Provide pipe chases with double wall, insulated panels. Pipe chase shall have the same thermal performance as the unit casing.

B. Provide a perimeter base rail and/or roof curb under the pipe chase(s) that meets requirements for the AHU base rail and/or roof curb.

C. Manufacturer may combine the pipe chase enclosures of adjacent segments.

D. Provide a minimum pipe chase depth, as shown on drawings. Pipe chase depth is the clear inside dimension from inner pipe chase surface to outer unit surface.

E. Manufacturer may ship pipe chases separate from AHU if the chases are provided with lifting lugs for field installation per the AHU base rail requirements. Manufacturer shall provide step-by-step instructions with illustrations for proper pipe chase installation.

2.09 ROOF CURBS

A. Provide factory-fabricated galvanized steel roof curb for outdoor units. Roof curb shall support the full-perimeter of the air handling equipment, including pipe chases.

B. Match roof curb to roof slope. Curb surface shall be level in both axes.

C. Provide wood nailing strip to which roofer may nail roof flashing.

D. Ship roof curb loose for field installation prior to unit placement.

2.10 FANS

A. Provide double width double inlet (DWDI) housed fans or single width single inlet (SWSI) plenum fans as equipment schedule and drawings.

B. Airfoil fans shall comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA Seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.

C. Provide fans with true airfoil blades unless otherwise scheduled.

[Tip 20]: True airfoil fans are desirable as they offer higher efficiency and have a non-overloading fan characteristic.

D. Provide fans with the following accessories:

1. Fan inlet screens in the inlets of fan housing (REQUIRED on SWSI plenum fans)
2. Access door inlet screen (on AHU casing)
3. OSHA-compliant belt guard enclosing the fan motor and drive

E. Provide airfoil fans with blades formed of extruded aluminum, as scheduled. Bent sheet metal blades are not acceptable.

F. Provide an access door in the fan scroll, as shown on drawings.

G. Provide fans with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.

H. Provide fan motor on an adjustable base to allow adjustable and consistent belt tension.

I. Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame. Manufacturers not complying with this requirement must submit detailed structural and weight data to a licensed structural engineer for review and stamped certification. The mechanical engineer shall review these engineers' final reports prior to submittal approval.

[Tip 21]: Under no circumstances should the fan and motor assembly mount to the AHU casing floor. This would lead to excess casing vibration poor acoustics, panel fatigue and air leakage.

J. Provide vibration isolation springs with 1" or 2" static deflection, as scheduled.

K. Connect DWDI fans to the unit casing or bulkheads with canvas flexible connection.

L. Provide horizontal thrust restraints between AHU casing and fan housings with end discharge. This requirement applies to the following cases:

1. SWSI fans operating at greater than 3" of total static pressure
2. DWDI airfoil fans operating at greater than 6" of total static pressure
3. DWDI airfoil fans operating at greater than 3" of total static pressure

2.11 BEARINGS AND DRIVES

A. Provide bearings complying with ANSI/AFBMA 9 for fatigue life ratings.

B. Provide fan bearings with an average life L50 of at least 200,000 hours.

[Tip 22]: L-50 implies that bearings have a 50% chance of failure during 200,000 hours of operation. L-10 bearings have only a 10% chance of failure during the same time period.

C. Provide fan bearings with an average life L10 of at least 200,000 hours, as scheduled.

[Tip 23]: L-50 implies that bearings have a 50% chance of failure during 200,000 hours of operation. L-10 bearings have only a 10% chance of failure during the same time period.

D. Provide permanently lubricated bearings on forward curved fans smaller than 18." On other fans, provide re-greaseable bearings with hydraulic grease fittings and lube lines extended to the motor side of the fan or to the exterior of the unit (primary access side).

E. Provide plenum fans with direct-drive transmissions.

[Tip 24]: Direct drive plenum fans provide higher levels of efficiency and are typically quieter than belt-driven fans.

GUIDE SPECIFICATIONS

F. Provide drives selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Provide a fixed pitch sheave on the motor.

G. Provide fixed pitch sheaves on both the fan and motor. Fans with motors rated at 15 hp or less may be field balanced using variable pitch sheaves. Provide fixed pitch sheaves when final balance is complete. Air balancer shall select and provide final set of sheaves.

H. Provide multiple belt drives on belt driven fans with motors 10 hp or greater. Belts shall be V-type, precision molded, raw edge construction, anti-static, oil-resistant and heat-resistant.

2.12 ELECTRICAL MOTORS

A. Provide fan motors built in accordance with the latest standards of the NEMA and IEEE.

B. Provide AHU and fan motors in compliance with ASHRAE 90.1.

[Tip 25]: ASHRAE 90.1 has a detailed requirement for motor efficiency – typically requiring what manufacturer's call "premium" efficiency motors. 90.1 also has a detailed requirement for motor SIZE, depending on the application, static pressure, etc.

C. Provide fan motors with the following characteristics:

1. 60 hertz, 1750 rpm operation
2. Service factor of 1.15
3. Premium efficiency, or as required to meet ASHRAE 90.1
4. NEMA design ball bearing type
5. Rated for continuous duty at full load in a 104°F (40°C) ambient
6. Open drip proof (ODP) or totally enclosed, fan cooled (TEFC) as scheduled.
7. Suitable for use in variable frequency application, per NEMA MG-1 Part 30
8. Inverter ready per NEMA STD MG1 PART 31.4.4.2

D. Provide direct drive plenum fans coupled to motors with matching speed, as scheduled.

2.13 FAN-MOTOR DISCONNECTS

A. Provide UL or ETL listed fan-motor disconnects and associated components, as scheduled and shown on drawings. Disconnects shall comply with applicable provisions of the National Electric Code.

B. Provide fused or non-fused fan-motor disconnects in NEMA 1, NEMA 3R, NEMA 4, or NEMA 12 enclosures, as scheduled and shown on drawings.

C. Mount disconnects on the primary access side of the associated fan segment.

1. Mount unit main disconnect (on units with single point power) on the primary access side of supply fan section.

D. Disconnect shall be suitable for use as an OSHA lockout/tagout disconnect when applied in accordance with part IV, Department of Labor OSHA 29 CFR Part 1910, Control of Hazardous Energy Source (lockout/tagout): final rule.

E. Disconnect handles shall be lockable in the "off" position with up to three padlocks. Switch mechanism shall be directly lockable in the "off" position via padlock when door is open.

F. Provide disconnects with integral ground lug.

1. Provide two (2) #14 ground wires on 16A to 100A disconnects.
2. Provide one (1) #6-250 ground wire on 200A to 400A disconnects.

G. Provide auxiliary contacts, as scheduled.

2.14 FAN-MOTOR STARTERS

A. Provide UL or ETL listed motor starters and associated components, as scheduled and shown on drawings. Starters shall comply with applicable provisions of the National Electric Code.

B. Provide starter in a NEMA 3R enclosure.

C. Mount starter on the primary access side of its associated fan section, and wire starter to motor, unless shown otherwise on drawings.

D. Provide the following features in each starter panel:

1. Main power block
2. Motor contactor(s)
3. Individual starter short circuit and overload protection devices
4. Two primary control fuses, one secondary control line size fuse
5. Three phase ambient compensated overload heater elements
6. 115-volt control power transformer with primary and secondary protection
7. Five-point terminal strip for field control connections
8. Factory wired, non-fused or fused main power disconnect, integral with starter panel
9. Integrated on/off auto switch.
10. Wiring to fan motor

E. Starters on outdoor units shall be suitable for use in ambient temperatures from 5°F to 104°F:

1. Provide low ambient temperature kit suitable for use down to -20°F.
2. Provide high ambient temperature kit suitable for use up to 135°F.

2.15 FAN-MOTOR VARIABLE FREQUENCY DRIVES (VFDS)

A. Provide UL or ETL listed VFDs and associated components, as scheduled and shown on drawings. VFDs shall comply with applicable provisions of the National Electric Code.

B. Mount VFDs in a dedicated NEMA 1 compartment located on the primary access side of its associated fan section and wire VFD to motor, unless otherwise indicated on drawings.

C. Enclose outdoor VFDs in a NEMA-3R enclosure.

D. VFDs on outdoor units shall be suitable for use in ambient temperatures from 5°F to 104°F:

1. Provide low ambient temperature kit suitable for use down to -20°F.
2. Provide high ambient temperature kit suitable for use up to 135°F.

GUIDE SPECIFICATIONS

E. After unit installation, VFD shall be started and programmed by a factory trained and employed service technician. Refer to Section 3.05.

F. Provide the following VFD disconnect and bypass option:

1. Fused main disconnect
2. 2 contactor VFD bypass
3. 2 contactor VFD bypass with fused disconnect
4. 2 contactor VFD bypass with non-fused disconnect

[Tip 26]: Select from item a, b, c or d. Consider that VFDs are a mature, proven and highly reliable technology. Bypass packages are therefore not as important as they used to be. Perhaps specifying a spare drive in lieu of bypass packages on drives is a better value for the owner.

G. Provide harmonic distortion feedback protection:

1. Equivalent 5% impedance input line reactor
2. Integral RFI/EMI filtering to meet EMC EN61800-3 for First Environment

H. Provide a user interface with the following features:

1. 30 Character multi-lingual alphanumeric display
2. Parameter set-up and operating data
3. Display data shall include:
   a. output frequency (Hz)
   b. speed (RPM)
   c. motor current
   d. calculated % motor torque
   e. calculated motor power (kW)
   f. DC bus voltage
   g. output voltage
   h. heat sink temperature
   i. elapsed time meter (re-settable)
   j. kWh (re-settable)
   k. input / output terminal monitor
   l. PID actual value (feedback) & error
   m. fault text
   n. warning text
   o. scalable process variable display

I. Provide VFD with the following protection circuits:

1. over current
2. ground fault
3. over voltage
4. under voltage
5. over temperature
6. input power loss of phase
7. loss of reference/feedback

8. adjustable current limit regulator

J. VFD shall be UL 508C approved for electronic motor overload (12t).

K. Provide high input transient protection and surge suppression

1. 4 MOVs ahead of diode bridge
2. 120 Joule rated 1600V diode module
3. Compliant with UL 1449 / ANSI 61.4

L. Provide the following communication features:

1. Two programmable analog inputs
2. Six programmable digital inputs
3. Two programmable analog output
4. Three programmable digital relay outputs
5. Modbus RTU Communications protocol
6. Adjustable filters on analog inputs and outputs
7. Input speed signals, including 4-20 mA and 0-10 VDC
8. Accel/Decel contacts (floating point control)
9. Auto restart (customer selectable and adjustable)
10. Start/Stop options shall include 2 wire (dry contact closure), 3 wire (momentary contacts), application of input power, and application of reference signal (PID sleep/wake-up)
11. Integrated control interface for Siemens FLN, Johnson N2, Modbus RTU, or BACnet MS/TP or LONworks over RS-485.

M. Provide the following functions:

1. Premagnetization on start
2. DC braking/hold at stop
3. Ramp or coast to stop
4. Seven preset speeds
5. Three critical frequency lockout bands
6. Start function shall include ramp, flying start, automatic torque boost, and automatic torque boost with flying start

2.16 FACTORY INSTALLED ELECTRICAL ACCESSORIES

A. In addition to motor power terminals, provide an independent power terminal for convenience receptacles and lights. Provide switches as shown on drawings.

B. Provide incandescent or fluorescent lights in segments as scheduled or shown on drawings. Provide light switches as scheduled or shown on drawings.

C. Provide a 1-hour timer on external light switches.

D. Provide a 120v convenience receptacle on supply fan segment.

2.17 HEATING AND COOLING COMPONENTS

A. Provide coils manufactured by AHU manufacturer, except where noted in contract documents.

GUIDE SPECIFICATIONS

B. Coils shall meet or exceed performance scheduled on drawings.

1. When applicable, provide coils with performance certified in accordance with ARI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at design flow.

C. Provide cooling coils with a maximum face velocity of 550 fpm or 500 fpm or 450 fpm. Face velocity calculations shall be based on the finned area of the coil.

[Tip 27]: Coils with higher face velocities are more vulnerable to moisture carryover. A coil's vulnerability to condensate carryover depends on the coil design. Coils with densely packed fins (12 or 14 fpi) are more vulnerable. Coils with staggered tube arrangements (YORK standard) are less vulnerable. The cleanliness of a coil also matters.

D. Provide cooling coil drain pan that is sufficient to contain coil condensate. Drain pan shall extend a minimum of 6" or 10" or 14" downstream of the face of the coil.

[Tip 28]: YORK coils are designed and selected to prevent moisture carryover. However, dirty coils or coils operating under non-design conditions may lead to carryover moisture. Therefore, YORK recommends at least 6" of drain pan downstream to catch moisture. More drain pan is better, as it will keep moisture from reaching downstream components such as fans and fan motors.

E. Provide coil segment casing to accommodate full-face or reduced-face coils as scheduled. Provide face and bypass coil segments with factory installed bypass damper.

F. Provide at least 18" or 24" or 30" of access between coils. Provide an easily operable access panel or door, as shown on drawings.

G. Provide coil segment casing that meets or exceeds casing performance of the unit.

[Tip 29]: Because the coil segment is the coldest part of the AHU, thermal performance, leakage and deflection are critical here. Cooling coil drainpans are typically the root of an AHU's IAQ problems, making performance even more critical.

H. Provide panels that are easily removable with no special tools.

I. Locate access doors to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.

J. Provide coils built in their own full perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing and support members shall not block finned area.

K. Individual coils shall be removable from the side of the AHU.

L. Provide an intermediate drain pan on stacked cooling coils. Intermediate drain pan shall slope in a minimum of two planes toward a single drain connection.

M. Provide a single intermediate vertical coil support on coils with a finned length greater than 62". Provide two vertical supports on coils with a finned length greater than 100", and three vertical supports on coils with a finned length greater than 141".

N. Extend coil connections through AHU casing. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow complete draining and venting when installed. Vent and drain connections shall be on the coil connection extension outside of the unit casing.

O. Insulate gap between coil stub out connection and AHU casing with a spool-shaped sleeve grommet. Adhesive rings applied the casing walls are not acceptable.

[Tip 30]: Coil penetrations are a very common leakage point. Not only can air leak through the casing, but it can also leak into individual panels. This leads to a loss in IAQ and energy efficiency performance. Spec a tight seal by specifying coil connections that are extended through the casing, and by specifying a spool-shaped grommet seal that isolates the coil connection from the panel, and that isolates the interior of the unit from the exterior. Coil penetrations are a very common leakage point. Not only can air leak through the casing, but it can also leak into individual panels. This leads to a loss in IAQ and energy efficiency performance. Spec a tight seal by specifying coil connections that are extended through the casing, and by specifying a spool-shaped grommet seal that isolates the coil connection from the panel, and that isolates the interior of the unit from the exterior.

P. Water and glycol coils shall be operable at 250 psig working pressure and up to 300° F. Factory test water and glycol coils with 325 psig compressed air under water.

Q. Direct expansion (DX) coils shall conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a maximum refrigerant pressure of 250 psig. Factory test DX coils with 325 psig compressed air under water.

R. Steam distributing coils shall be operable at 50 psig pressure and a corresponding saturated steam temperature of 298° F. Factory test steam coils with 315 psig compressed air under water. Dehydrate and seal coils prior to shipping.

S. Provide steam-distributing coils with a tube outer diameter (OD) of 1" and an inner distribution tube of 5/8" O.D. Circuit coils for gravity drain of condensate without trapping. Steam shall discharge in the direction of condensate flow to ensure even heat transfer across each tube.

T. Provide water, glycol and DX coils with a tube OD of 5/8" or 1/2". Mechanically expand tubes to form fin bond and provide burnished, work-hardened interior surface. Tubes shall have a minimum tube wall thickness of 0.020" or 0.025" or 0.035" or 0.049" for 5/8" tubes, and 0.016" or 0.020" or 0.032" for 1/2" tubes.

U. Provide coils with copper tube return bends with the following final minimum thicknesses:

   1. 0.035" for 5/8" diameter tubes
   2. 0.032" for 1/2" diameter tubes with 0.020" or 0.032" tube wall thicknesses
   3. 0.020" for 1/2" diameter tubes with 0.016" tube wall thickness.

[Tip 31]: The outer radius of a coil tube's return bend can be very vulnerable to premature failure. Tubes that are machine bent to create a return bend are especially susceptible to failure, as the outer radius of the bend is stretched and has a final thickness that is significantly thinner than the initial tube thickness. Specifying and enforcing a FINAL thickness of .035" at the outer radius of the return bend will help ensure a robust and long-lasting coil

V. Provide water, glycol and steam coil headers made of seamless copper or brass tubing. Pipe connections shall be steel or red brass. Header connections (tubes and piping connections) shall be silver-brazed or TIG welded.

W. Provide DX coils with brass distributor and solder-type connections. Suction and discharge connections shall be on the same end regardless of coil depth. Mount refrigerant specialties outside of unit. Provide DX coils with a hot gas bypass port on distributor.

X. Provide coils with die-formed, continuous aluminum or copper fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.006" or 0.008 or 0.01" thick.

Y. Provide coil coatings as scheduled or indicated on drawings.

2.18 FILTERS

A. Provide filter segments and filters as scheduled.

B. Provide side loading filters for filter segments located upstream of coil segment(s) with an access door on the drive side through which filters can be easily loaded.

C. Provide face loading filters for segments located downstream of coil segment(s). Provide an 18" (minimum) access plenum and access door on the drive side through which face loading filters can be easily loaded.

[Tip 32]: Face loading filters offer a tighter seal and less air bypass than side loading filters. For performance reasons, it is best to not use side loading filters in downstream or "final" positions, where the filters typically have high efficiencies. Be sure to specify generous access, as they require space upstream or downstream of the rack to change filters.

D. Provide filter racks integral to the unit and constructed of galvanized steel or stainless steel.

E. Provide Class 2 or Class 1 filter media per U.L. 900 and as required by local codes.

F. Filter types, efficiencies, and nominal depths shall be as follows:

   1. Flat filters – 2" throwaway, 2" permanent cleanable, 2" 30% pleated, or 4" 30% pleated filters, as scheduled.
   2. Angled filters – 2" throwaway, 2" permanent cleanable, or 2" 30% pleated filters, as scheduled.

3. Rigid filters – 4" mini pleated, 12" rigid, or 22" bag filters with efficiencies of 60-65% (MERV 11), 80-85% (MERV 13), 90-95% (MERV 14), or 90-95% (MERV 15), respectively; as scheduled.
    a. Provide a pre-filter rack in rigid filter segments. Pre-filters shall have 2" throwaway, 2" permanent cleanable, 2" 30% pleated, or 4" 30% pleated filters as scheduled.
4. Carbon filters – 2" deep rechargeable, incinerable, or disposable panels filled with 60% activity carbon, as scheduled.
    a. Carbon filtration system shall be designed for a minimum contact efficiency of 99% with a residence time of at least 0.08 seconds.
    b. Provide post-filter and/or pre-filter rack in carbon filter segments with 2" throwaway, 2" permanent cleanable, 2" 30% pleated, or 4" 30% pleated filters, as scheduled.
5. HEPA filters – 12" 99.97%, or 99.99% efficient media, as scheduled.
    a. Performance of installed filtration system shall be certified via a DOP test and classified as UL Class 1 when tested in accordance with UL Standard 586.
    b. Filter frame shall be specifically developed for HEPA filters, with appropriate quantities of filter clamps.

G. Provide a flush mounted, factory installed magnahelic differential pressure gage on the drive side of unit to measure pressure drop across filters. Manufacturer shall provide fully functional gauges, complete with tubing.

2.19 DAMPERS

A. Provide dampers tested in accordance with AMCA 500.

B. Provide factory-installed dampers, as shown on drawings.

C. Dampers shall have airfoil blades, extruded vinyl edge seals, and flexible metal compressible jamb seals.

D. Dampers shall have a maximum leakage rate of 4 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1.

E. Damper blades shall be parallel acting unless otherwise indicated.

F. Damper blades shall be galvanized steel or aluminum, as scheduled.

2.20 AIRFLOW MONITORING STATIONS

A. Provide airflow monitoring stations, as scheduled or shown on drawings.

B. Provide airflow monitoring stations tested in accordance with AMCA Standard 611 in an AMCA registered laboratory. Airflow monitoring stations shall bear the AMCA Ratings Seal for Airflow Measurement Performance.

C. If airflow station incorporates a control damper, control damper shall comply with leakage rates per ASHRAE 90.1 and with specification section 2.19 DAMPERS.

D. Provide a factory-installed transducer that sends a CFM-proportional, 4-20 mA or 0-10V signal, as specified.

2.21 DIFFUSERS

A. Provide diffuser segments as shown on drawings.

B. Diffuser plates shall ensure proper air flow across components downstream of DWDI fans.

2.22 APPURTENANCES

A. Provide rain hoods on outdoor unit air intakes, as shown on drawings. Provide moisture screens on outdoor air inlet rain hoods.

B. Provide safety grates over bottom openings, as shown on drawings.

1. Safety grates shall be capable of supporting a 300 lb. center load.

2.23 FINISHES

A. Manufacturer shall clean the exterior surfaces of units prior to finishing, painting, or shipment.

B. Manufacturer shall paint outdoor units prior to shipment. Manufacturer shall paint indoor units, as scheduled or shown on drawings.

1. Manufacturer shall apply a primer prior to painting units.
2. Manufacturer shall apply a finish coat of acrylic polyurethane paint.
3. Finished unit shall exceed 500-hour salt spray solution (5%) test without any sign of red rust when tested in accordance with ASTM B-117.

2.24 TESTS AND INSPECTIONS

A. Manufacturer shall dynamically balance fan/motor/base assembly.

1. Balance constant volume fan assemblies at design RPM.
2. Balance variable volume fan assemblies from 10% to 100% of design RPM.
3. Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
4. Take filter-out measurements in the horizontal, vertical, and axial axes on the drive and opposite-drive side of fan shafts.
5. Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils. Filter-out measurements shall not exceed 6 mils in the horizontal and vertical axes, and 7 mils in the axial axis.
6. Variable speed fan vibration limits: filter -in measurements shall not exceed 7 mils. Filter-out measurements shall not exceed 9.5 mils.

B. Manufacturer shall hipot test wiring intended to carry voltages greater than 30Vac.

2.25 VERIFICATION OF PERFORMANCE

A. Factory test one out of every five AHUs (or a minimum of one unit) to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements. Owner and engineer reserve the right to select units to be tested. Manufacturer shall pay food, lodging, and travel expenses for up to two witnesses.

1. Alternatively, field test units to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements. Follow testing procedures outlined in this specification. Manufacturer shall hire a mechanical engineer of record to supervise testing.

B. One representative from both the owner and the engineer shall witness the test. Manufacturer shall pay food, lodging and transportation expenses for two witnesses.

C. Perform test on a fully assembled unit with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, caulk) is not acceptable.

D. Perform tests to verify the following performance criteria:

1. Casing leaks no more than 1% of design CFM at +/-8" w.g.
2. Casing panels deflect no more than L/240 at +/-8" w.g. 'L' is defined as the panel span length and 'L/X' is the deflection at panel midpoint.

[Tip 33]: Make sure that bidders to your specification are held accountable for their performance. Specifying leakage and deflection tests are an important part of ensuring the owner gets the performance that was specified.

E. Unit shall meet the Large Missile Impact Test for AHU casing (walls, roof, and doors) and base. Unit shall carry a Notice of Acceptance (NOA) from the Miami-Dade County Product Control Division. Label equipment per NOA labeling instructions.

F. Provide written letter of guarantee from manufacturer stating that no condensation will form on the exterior of units, under given design conditions.

[Tip 34]: It is not practical or reasonable to test for thermal performance or sweating. However a manufacturer should know their performance capabilities and should willingly write this letter.

G. Should a unit fail a test, treat unit with a permanent remedy at manufacturer's expense until test is successfully passed.

2.26 FACTORY TEST SETUP AND METHODS

A. AHU Preparation

1. Assemble and seal AHU sections per manufacturer's installation manual.
2. Close and latch access doors. No additional sealing is permitted.
3. Seal duct, damper and louver openings.
4. Blank off and seal supply fan opening(s).
5. Blank off and seal supply fan bulkhead to isolate positive and negative pressure sections.

B. Pressurization procedure

1. Pressurize positive pressure side to specified static pressures using a pressure blower.
2. Pressurize negative pressure side to specified static pressures using a pressure blower.
3. Measure and monitor differential pressure exerted on the cabinet with a pressure gage.

C. Test measurement

1. Measure panel deflections at the centers (length and width) or four panels chosen by owner and engineer.
2. Measure pressure drop through an ASME long radius nozzle, mounted n the test module.
3. Monitor leakage at the same time panel deflection is measured.

D. While under pressure, inspect units failing to meet specified leakage and deflection. Treat failing areas with a permanent remedy. Repeat test and inspection. Re-treat unit as necessary to pass both tests.

E. Provide test data and results in a complete report to the owner.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.

B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.

C. Install AHUs on a concrete pad, roof curb, or structural steel base, as shown on drawings.

D. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal.

E. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of transfer to owner.

F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions.

G. Install seismic restraints and anchors per applicable local building codes. Refer to specification Section 230548 (15240 / 15070) for product and installation requirements.

H. Install pipe chases per manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer's instruction for long-term storage.

[Tip 35]: Improper storage can degrade the longevity and performance of an AHU. Rust and bacteria may form if units are not kept dry. IAQ and energy efficiency may be negatively impacted once improperly stored AHUs are operating.

B. Rig and lift units according manufacturer's instructions.

3.03 AHU INSPECTION

A. Hire manufacturer's factory-trained and factory-employed service technician to perform an inspection of unit and installation prior to startup. Technician shall inspect and verify the following as a minimum:

[Tip 36]: A thorough inspection and necessary corrections ensure a proper installation. A proper installation is necessary to fully realize the energy, IAQ and acoustical benefits of a high-performance AHU and system.

1. Damage of any kind
2. Level installation of unit
3. Proper reassembly and sealing of unit segments at shipping splits.
4. Tight seal around perimeter of unit at the roof curb
5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
6. Completion and tightness of electrical, ductwork and piping connections
7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
8. Supply of electricity from the building's permanent source
9. Integrity of condensate trap for positive or negative pressure operation
10. Condensate traps charged with water
11. Removal of shipping bolts and shipping restraints

12. Sealing of pipe chase floor(s) at penetration locations.
13. Tightness and full motion range of damper linkages (operate manually)
14. Complete installation of control system including end devices and wiring
15. Cleanliness of AHU interior and connecting ductwork
16. Proper service and access clearances
17. Proper installation of filters
18. Filter gauge set to zero

B. Resolve any non-compliant items prior to proceeding with the inspection of the fan assembly.

3.04 INSPECTION AND ADJUSTMENT: AHU FAN ASSEMBLY

A. Hire the manufacturer's factory-trained and factory-employed service technician perform an inspection of the AHU fan assembly subsequent to general AHU inspection and prior to startup. Technician shall inspect and verify the following as a minimum:

[Tip 37]: A thorough inspection and adjustment of the fan assembly helps ensure that the energy, IAQ and acoustical benefits of a high-performance AHU and system are realized.

1. Fan isolation base and thrust restraint alignment
2. Tight set screws on pulleys, bearings and fan
3. Tight fan bearing bolts
4. Tight fan and motor sheaves
5. Tight motor base and mounting bolts
6. Blower wheel tight and aligned to fan shaft
7. Sheave alignment and belt tension
8. Fan discharge alignment with discharge opening
9. Fan bearing lubrication
10. Free rotation of moving components (rotate manually)

B. Manufacturer shall perform service to bring fan performance within factory specifications.

3.05 STARTUP SERVICE AND OWNER TRAINING

A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:

1. Energize the unit disconnect switch
2. Verify correct voltage, phases and cycles
3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.

B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include AHU controls, motor starter, VFD, and AHU.

C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.

D. If AHU is provided with a factory-mounted variable frequency drive (VFD), hire the VFD manufacturer's factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.

E. Submit a startup report summarizing any problems found and remedies performed.

3.06 FIELD PERFORMANCE VERIFICATION

A. Leakage: Pressurize casing to +/-8" w.g. and measure leakage. Pressurize casing to –8"w.g. and measure leakage. If leakage exceeds 1% of design airflow, seal leakage points with a permanent solution. Repeat test. If the AHU still does not pass, contact the manufacturer to seal unit.

B. Submit a field test report with testing data recorded. Include description of corrective actions taken.

[Tip 38]: A field leakage test is a prudent step to ensure that the AHU performs as promised. The test is a final confirmation that the AHU will perform. Field testing confirms that the AHU withstood the stresses of shipping, rigging and installation and can still provide high performance.

3.07 CLEANING

A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.

B. Clean exterior prior to transfer to owner.

3.08 DOCUMENTATION

A. Provide Installation, Operation & Maintenance Manuals in the supply fan section of each unit. Provide six additional copies for owner's project system manual.

B. Provide six copies of Spare Parts Manual for owner's project system manual.

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